

Shared Mobility and the Transformation of Public Transit

**Sharon Feigon
Colin Murphy
Shared-Use Mobility Center
Chicago, IL**

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Table of Contents

Acknowledgments	ii
Executive Summary	iv
Introduction	1
Definition of Terms.....	2
Research Overview	4
Findings	
1: Transportation and Lifestyle Choices Associated with Shared Mode and Transit Use	6
2: Shared Mode and Transit Usage Patterns.....	13
3: Equity in an Expanding Mobility Marketplace.....	23
4: Public-Private Collaborations around Paratransit.....	29
5: Emerging Mobility Business Models and Partnerships	34
Conclusions	39
Appendices	42
Appendix A: Public Agency and Private Operator Interviewees	A-1
Appendix B: Survey Methodology and Additional Data	A-4
Appendix C: Survey Instrument.....	A-9
Appendix D: Ridesourcing and Transit Travel Time Comparison	A-20
Appendix E: Ridesourcing Demand and Transit Capacity Calculation.....	A-30
Appendix F: Maps of Ridesourcing and Transit Demand and Capacity.....	A-33

Executive Summary

Technology is transforming transportation. The ability to conveniently request, track, and pay for trips via mobile devices is changing the way people get around and interact with cities. This report examines the relationship of public transportation, including paratransit and demand responsive services, to shared modes, including bikesharing, carsharing, microtransit, and ridesourcing services provided by companies such as Uber and Lyft. The research included participation by seven cities: Austin, Boston, Chicago, Los Angeles, San Francisco, Seattle and Washington, DC.

Some transportation observers have predicted that, by creating a robust network of mobility options, these new modes will help reduce car ownership and increase use of public transit, which will continue to function as the backbone of an integrated, multimodal transportation system.

The objective of this research was to examine these issues and explore opportunities and challenges for public transportation as they relate to technology-enabled mobility services, including suggesting ways that transit can learn from, build upon, and interface with these new modes.

To accomplish this task, the study draws on several sources of information, including:

- In-depth interviews with transportation officials
- A survey of shared mobility users;
- Analysis of transit and ridesourcing capacity, demand, and comparative travel times;
- An assessment of practices and regulations relating to paratransit provision; and
- A compilation of current business models and public-private partnerships that build on new technologies from the emerging shared mobility sector.

Together, these elements provide a snapshot of a rapidly widening mobility ecosystem at an early moment in its evolution, and form the basis for a number of recommendations for balancing the benefits of innovation with public agencies' responsibility to the common good.

Key Findings

1. **Among survey respondents, greater use of shared modes is associated with greater likelihood to use transit frequently, own fewer cars, and have reduced transportation spending.** "Supersharers"—people who routinely use several shared modes, such as bikesharing, carsharing, and ridesourcing—report the greatest transportation savings and own half as many cars as people who use transit alone.
2. **Shared modes largely complement public transit, enhancing urban mobility.** However, they may compete with transit on some routes and at certain times of day. Ridesourcing services are most frequently used for social trips between 10 p.m. and 4 a.m., times when transit runs infrequently or is unavailable. Bikesharing plays a peak hour role in augmenting transit systems, while carsharing is mostly used off peak. The car-based shared modes likely substitute more for taxi or automobile trips than transit trips. Transit is most competitive when it travels in its own right of way and provides frequent service.
3. **Because shared modes are expected to continue growing in significance, public entities should identify opportunities to engage with them to ensure that benefits are widely and equitably**

shared. Transit agencies can improve urban mobility for the entire spectrum of users through collaboration and public-private partnerships, including greater integration of service, information, and payment methods.

4. **The public sector and private mobility operators are eager to collaborate to improve paratransit using emerging approaches and technology.** While a number of regulatory and institutional hurdles complicate partnerships in this area, technology and business models from the shared mobility industry can help lower costs, increase service availability, and improve rider experience.
5. **A number of business models are emerging that include new forms of public-private partnership for provision of mobility and related information services.** Public entities, including transit agencies and local transportation departments, are already engaging with private operators and using new technologies from the shared mobility world. There are many examples on the ground that public agencies can already look to for insight. Key areas of collaboration are in cross-modal trip planning, reservation, and payment application integration; microtransit/dynamic demand response; private access to public rights-of-way; and service links and handoffs

Conclusions

This report concludes by presenting actions that public entities—transit agencies, transportation departments, and other local and regional agencies—can take to promote useful cooperation between public and private mobility providers. It also suggests regulatory enhancements, institutional realignments, and forms of public-private engagement that would allow innovation to flourish while still providing mobility as safely, broadly, and equitably as possible.

Introduction

This study focuses on the intersection of public transit and shared mobility in seven US metropolitan regions of varying character, whose transit systems represent a range of sizes and maturities. Some are lower density, younger cities that have experienced high levels of urban growth in recent decades, but have little tradition of public transit use and are primarily dependent on individual autos. At the other end of the spectrum are older cities with very dense cores and robust, widely used public transit systems. Basic characteristics of the regions and their transportation systems are listed in Table 1, below. Appendix A presents a list of the individuals interviewed from the public and private sectors in the seven regions.

Table 1. Summary of study cities' mobility characteristics.

Region	Metro area pop. (millions)	Core city pop. (millions)	Urbanized area (sq. mi.)	Metro area solo auto commute %; avg. household vehicle count	Carshare operators, vehicle count, total cars per 10,000 core pop.	Bikeshare operators, bike and station count, bikes per 10,000 core pop.	Ridesourcing and microtransit providers, launch year	Transit systems: total annual unlinked trips, millions (annual trips per capita)
Austin-Round Rock, TX	1.78	0.91	523	81.4% 1.77	Car2Go (one-way), Zipcar (traditional) 381 cars, 4.2/10K	Austin BCycle: 375 bikes, 46 stations 4.1/10K	Lyft, Uber 2014	Capital Metropolitan Transit Authority (CapMetro): 36.4 (26.7)
Boston-Cambridge-Newton, MA-NH	4.60	0.66	1873	72.0% 1.58	Enterprise, Zipcar (traditional) 1265 cars, 19.46/10K	Hubway: 1300 bikes, 139 stations 19.8/10K	Lyft, Uber 2012 Bridj (microtransit) 2014	Mass. Bay Transportation Authority (MBTA): 395.3 (94.5)
Chicago-Naperville-Elgin, IL-IN-WI	9.49	2.72	2443	74.1% 1.62	Enterprise, Zipcar (traditional) 790 cars, 2.9/10K Getaround (p2p) 120 cars, 0.4/10K	Divvy: 4760 bikes, 476 stations 17.5/10K	Lyft, Uber 2013 Via (microtransit) 2015	Chicago Transit Authority (CTA): 529.2 (61.5) NE Ill. Regional Commuter Railroad (Metra): 73.6 (8.6) Pace Suburban Bus: 35.9 (4.2) <i>Total: 638.7 (74.2)</i>
Los Angeles-Long Beach-Anaheim, CA	12.95	3.92	1736	77.7% 1.80	Zipcar (traditional and one-way) 241 cars, 0.6/10K	Planned, spring 2016	Lyft, Uber 2013	LA County Metropolitan Transportation Authority (Metro): 476.3 (39.2)

Shared Mobility and the Transformation of Public Transit

Region	Metro area pop. (millions)	Core city pop. (millions)	Urbanized area (sq. mi.)	Metro area solo auto commute %; avg. household vehicle count	Carshare operators, vehicle count, total cars per 10,000 core pop.	Bikeshare operators, bike and station count, bikes per 10,000 core pop.	Ridesourcing and microtransit providers, launch year	Transit systems: total annual unlinked trips, millions (annual trips per capita)
San Francisco-Oakland-Hayward, CA	4.40	0.85	524	65.1% 1.69	City CarShare, Enterprise, Scoot, Zipcar (traditional) 1315 cars, 15.5/10K Getaround (p2p) 1230 cars, 14.4/10K	Bay Area Bikeshare: 700 bikes, 70 stations 8.2/10K	Lyft, Uber 2011 Chariot (microtransit) 2014	San Francisco Municipal Railway (Muni): 223.9 (68.2) Bay Area Rapid Transit District (BART): 126.5 (38.6) <i>Total: 350.4 (106.8)</i>
Seattle-Tacoma-Bellevue, WA	3.50	0.67	1010	73.9% 1.83	Zipcar (traditional), car2go (one-way) 905 cars, 13.5/10K	Pronto: 500 bikes, 51 stations 7.5/10K	Lyft, Uber 2013	King County Metro Transit: 123.2 (40.3)
Washington-Arlington-Alexandria, DC-VA-MD-WV	5.76	0.66	1322	69.3% 1.76	Car2Go (one-way), Enterprise, Zipcar (traditional) 1680 cars, 25.5/10K Getaround (p2p) 105 cars, 1.48/10K	Capital Bikeshare: 1538 bikes, 204 stations 23.3/10K	Lyft, Uber 2011 Bridj, Split (microtransit) 2015	Washington Metropolitan Area Transit Authority (WMATA): 413.6 (90.2)

Sources: US Census Bureau American Community Survey 2014 5-year estimates (metro & city population, commute mode, household vehicles, occupied housing units); National Transit Database 2013 profiles (transit system data, service area population; trips per capita uses each transit agency's service area population); SUMC Shared Mobility Database (shared mobility operators and vehicle counts as of December 2015).

Definition of Terms

Because shared-use mobility is a relatively new field, the terms for various business models and technologies are still in flux. This study will use the following standard meanings for terms that might not yet be in common use or widely agreed upon. Table 2 summarizes the terms as they are used in this report, which generally conform to the definitions set out in the Transportation Research Board's Special Report 319 (2016)¹ and by Shaheen et al (2015)².

¹ Committee for Review of Innovative Urban Mobility Services, Transportation Research Board. *Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation Services*. TRB Special Report 319. (Washington, DC: Transportation Research Board, 2016)

² Shaheen, Susan, Nelson Chan, Apaar Bansal, Adam Cohen. "Shared Mobility: A Sustainability & Technologies Workshop: Definitions, Industry Developments, and Early Understandings." Whitepaper prepared for California Department of Transportation by UC Berkeley Transportation Sustainability Research Center. November 2015. http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf

Shared Mobility and the Transformation of Public Transit

Table 2. Definition of terms.

Term (abbreviation)	Meaning	Other Names/Treatments
Bikesharing	Short-term bike rental, usually for individual periods of an hour or less over the course of a membership (periods which can range from a single ride, to several days, to an annual membership). Information technology (IT)-enabled public bikesharing provides real-time information about the location and demand for bikes at docking stations throughout a community.	Bike sharing
Carsharing	A service that provides members with access to an automobile for intervals of less than a day. Major carsharing business models include <i>traditional</i> or <i>round-trip</i> , which requires users to borrow and return vehicles at the same location; <i>one-way</i> or <i>free-floating</i> , which allows users to pick up a vehicle at one location and drop it off at another; and <i>peer-to-peer (p2p)</i> , which allows car owners to earn money at times when they are not using their vehicles by making them available for rental to other carshare members.	Car sharing
Microtransit	IT-enabled private multi-passenger transportation services, such as Bridj, Chariot, Split, and Via, that serve passengers using dynamically generated routes, and may expect passengers to make their way to and from common pick-up or drop-off points. Vehicles can range from large SUVs to vans to shuttle buses. Because they provide transit-like service but on a smaller, more flexible scale, these new services have been referred to as “microtransit.”	Dynamic shuttles, private flexible transit
Private shuttles	Traditional private shuttle services include corporate, regional, and local shuttles that make limited stops, often only picking up specified riders.	Employer shuttles, “tech buses”
Ridesharing	At its core, ridesharing involves adding passengers to a private trip in which driver and passengers share a destination. Such an arrangement provides additional transportation options for riders while allowing drivers to fill otherwise empty seats in their vehicles. Traditional forms of ridesharing include carpooling and vanpooling. This term is sometimes used to refer to <i>ridesourcing</i> (see below) but unless otherwise noted, that is not the meaning employed in this report.	Carpooling, vanpooling, “slugging”
Ridesourcing	Ridesourcing providers such as Uber and Lyft—codified in California law as Transportation Network Companies (TNCs)—use online platforms to connect passengers with drivers and automate reservations, payments, and customer feedback. Riders can choose from a variety of service classes, including drivers who use personal, non-commercial, vehicles; traditional taxicabs dispatched via the providers’ apps, and premium services with professional livery drivers and vehicles. Ridesourcing has become one of the most ubiquitous forms of shared mobility.	Transportation network company (TNC); ridesharing; ride-hailing; e-hailing
Ride-splitting	Dedicated operators, as well as several ridesourcing providers, have launched IT-mediated products that allow customers requesting a ride for one or two passengers to be paired in real time with others traveling along a similar route.	Dynamic carpooling
Shared-use mobility (SUM), shared modes, SUM operators	In general, shared-use mobility comprises intra-urban transportation services in which vehicles are accessed by multiple users for a variety of trip purposes. This umbrella term includes the forms listed above along with traditional public transit, taxis, and other vehicles for hire.	Shared mobility

Research Overview

This study draws on several sources of information, including:

- Interviews with more than 75 public-sector transportation officials and private operator representatives from approximately 30 agencies and private companies (listed in Appendix A);
- A survey of more than 4,500 shared mobility users (detailed below and in Appendices B and C);
- Analysis of transit and ridesourcing comparative travel times (detailed in Appendix D) and capacity and demand (detailed in Appendices E and F);
- An assessment of practices and regulations relating to paratransit provision; and
- A compilation of current business models and public-private partnerships that build on new technologies from the emerging shared mobility sector.

Together, these elements provide a snapshot of a rapidly widening mobility ecosystem at an early moment in its evolution, and form the basis for a number of recommendations for balancing the benefits of innovation with public agencies' responsibility to the common good.

Survey Methodology

The user survey was distributed through both private shared-mobility operators and transit agencies in September and October 2015.

The survey sample frame included adult residents of the study regions who have used one or more shared-use modes, including transit. The researchers requested distribution by transit agencies and shared mobility operators in all of the seven study markets, and also in New York City. The recruitment method was through invitations emailed and distributed via social media by cooperating agencies and operators, inviting customers to complete a web-based survey instrument. A link was directly emailed by distribution partners to more than 75,000 email recipients in addition to a large number of newsletter and social media followers, and received 4,551 at least partial responses. Provider-specific links, called collectors, allowed tracking of response sources and permitted deactivation of particular channels at the end of a two-week open period. The overall count represents a net response rate of 6.0% for the sources the researchers were able to track.

Sampling Considerations

Because the researchers were limited to working with convenience samples in each market—those individuals able to be reached via the partners who agreed to distribute the survey, all of whom were people who had previously supplied their email addresses to the agencies or operators—we must be cautious about inferring to the wider population of shared mobility and transit users and certainly to the general population. The survey was administered via an online form, and links to this form were distributed by email. This implies a basic level of technological facility, and also a willingness to participate in research about transportation. Also, the survey took place in several of the largest, densest, and most expensive cities in the country, which were chosen for this study specifically because of their known high levels of shared mobility usage. Thus the sample is likely over-representative of higher-income, more highly educated individuals compared to the general US public.

We should also make note of the small sample sizes in some markets relative to others, particularly in Boston and San Francisco. In addition, we might expect some bias related to the mode of the distribution channels for the various surveys. In Los Angeles and San Francisco, the survey was

distributed almost exclusively via the transit agencies; in Boston, Chicago, and New York, the survey was distributed solely via bikeshare operators; and in Austin and Seattle the primary channel was a carsharing operator. One subpopulation this distribution method might miss would be people who use ridesourcing exclusively among shared modes, including transit. Unfortunately the researchers don't have a way of estimating the size of this population because so little systematic knowledge currently exists about levels of ridesourcing usage in urban areas and among the traveling population overall. Ongoing research—from other behavioral surveys, public and private operator data, personal travel inventories, and other data sources—is needed to continue building the understanding of the use and effects of ridesourcing and other shared modes.

The survey is described in greater detail in Appendix B, and the survey instrument is presented in Appendix C.

1: Transportation and Lifestyle Choices Associated with Shared Mode and Transit Use

Among survey respondents, greater use of shared modes is associated with greater likelihood to use transit frequently, own fewer cars, and have reduced transportation spending. “Supersharers”—people who routinely use several shared modes, such as bikesharing, carsharing, and ridesourcing—report the greatest transportation savings and own half as many cars as people who use transit alone.

An online survey of more than 4,500 mobility consumers in the study cities explored travel behaviors and attitudes, with a particular focus on the interaction of transit and new shared modes and associated effects on automobile ownership and use.³ It is important to note that the survey relied on convenience samples of transit and shared mobility users in several large cities, and is not necessarily representative of these populations overall, nor should it be interpreted as establishing causality in the behavior described by respondents. While this study finds evidence that shared modes appear to discourage automobile ownership and complement transit use overall, and in general focuses on the larger scale lifestyle changes made possible by new mobility options, the evidence also points to possible competitive impacts on transit operations in some specific situations. Additional and ongoing research is needed to more fully understand the net impacts and to track their changing nature over time and in other settings. Urban transportation is evolving rapidly, and even during the brief course of this research new transportation products came to market that may have impacts that were not studied in this work.

The survey found that rail and bus transit were the most frequently used shared modes, followed by bikesharing, carsharing, and ridesourcing (Figure 1). Some 10% of respondents could be classified as “supersharers”—people who had used at least three non-transit shared modes (bikesharing, carsharing, and ridesourcing) across some combination of trip purposes (commutes, errands, or recreation) within the last three months. The supersharers represent the group of people who take broadest advantage of the range of mobility options available to them. The results were notable. They are likely a group of early adopters, and are concentrated in urban areas, but their behavior can give some insights into how travel choices among the broader population may change as the mobility menu gets larger in more and more cities.

³ The survey methodology is detailed in the Background section above and in Appendix B, and the survey instrument is presented in Appendix C.

Shared Mobility and the Transformation of Public Transit

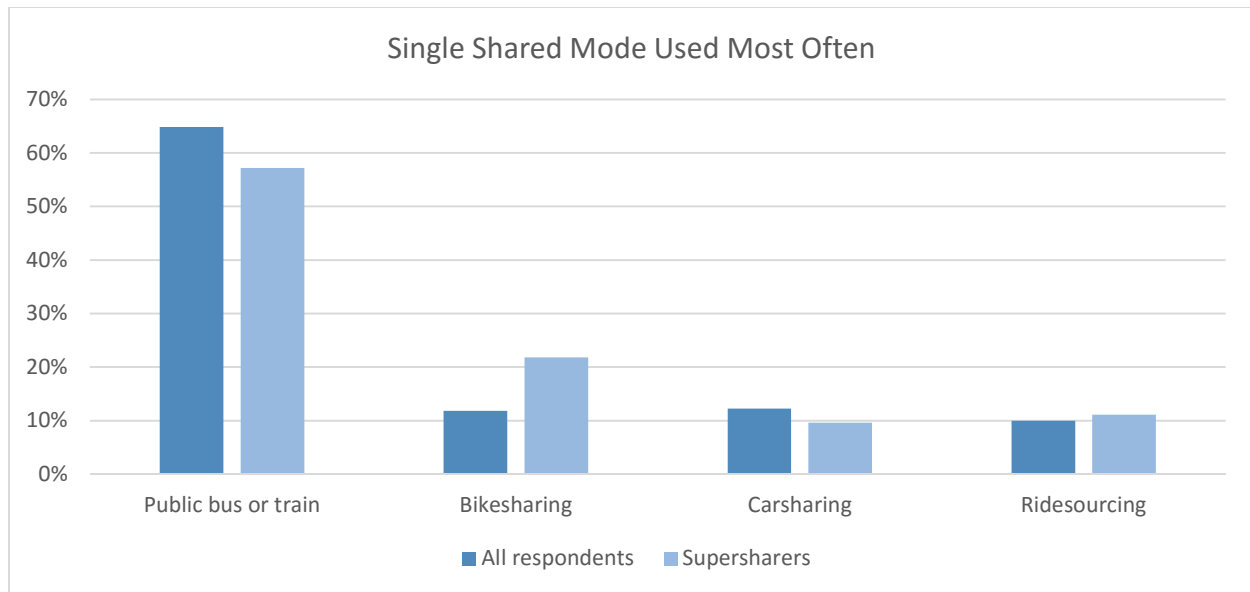


Figure 1: Single shared mode used most often--supersharers v. all respondents⁴

Approximately 57% of supersharers said public bus or train was the single shared mode they use most often, followed by bikesharing, ridesourcing, and carsharing (Figure 1). Asked about the entire range of mobility options rather than a single top mode, supersharers said they used transit and all of the other shared-use modes with frequency equal to or greater than the general respondents (Figure 2), and reported driving alone or with friends about 10% less than the overall group.

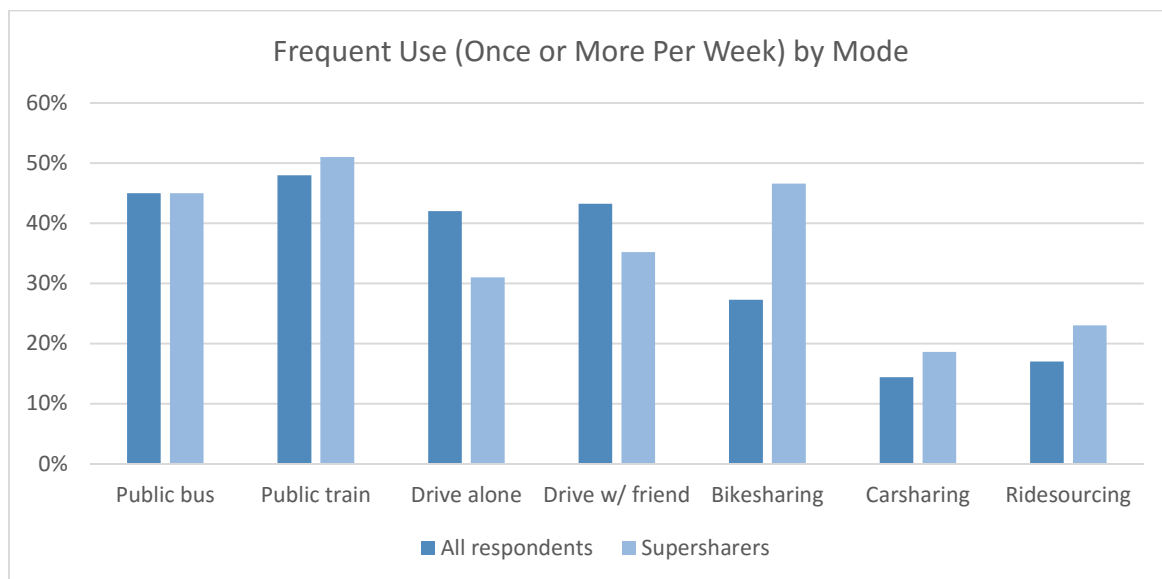


Figure 2: Frequent use (once or more per week) by mode—supersharers v. all respondents⁵

⁴ Q4: "Which shared-use service do you use most often?" Crosstabbed on Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

⁵ Q7: "How often do you travel in each of these ways?" Crosstabbed on Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

Asked how they would travel if their favored mode was not available (Figure 3), 30% of supersharers would choose another form of transit (18% bus, 12% train), about one quarter would use one of the other shared-use modes, and another quarter would ride their own bike or walk the whole way, for a 78% total of modes other than personal automobiles.

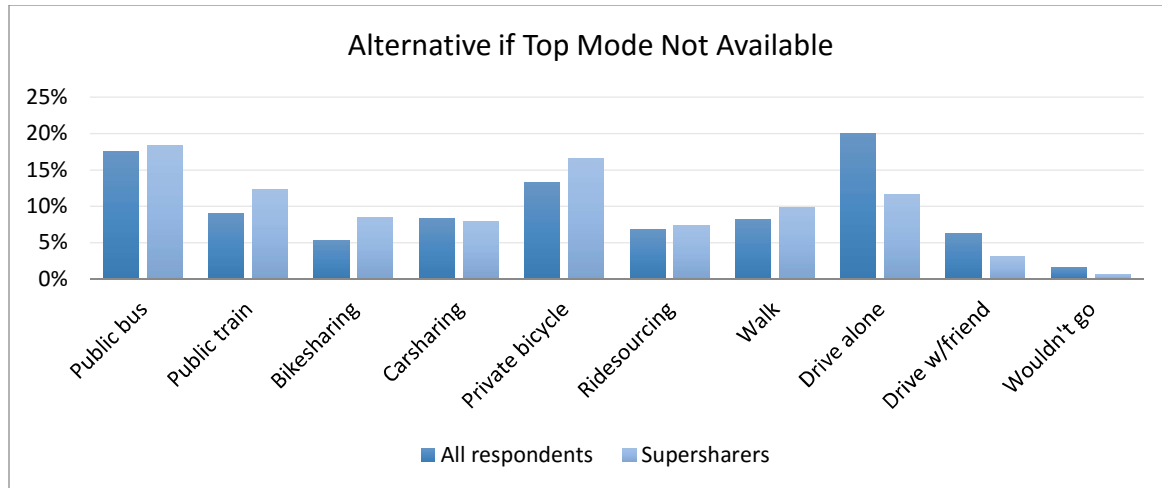


Figure 3: Alternative if top mode not available—supersharers v. all respondents⁶

We can further fill in the picture of how people mix and match various mobility options by looking at *all* of the modes respondents reported having used in the last three months (Figure 4). (Since the question Figure 4 is based on allows for choosing multiple modes for a given trip purpose, the figures represent the proportion of respondents who had used that mode for that purpose, and do not add to 100% across modes.)

⁶ Q5: "Thinking about the service you selected in the prior question, how would you make your most frequent trip if that service was not available?" Crosstabbed on Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

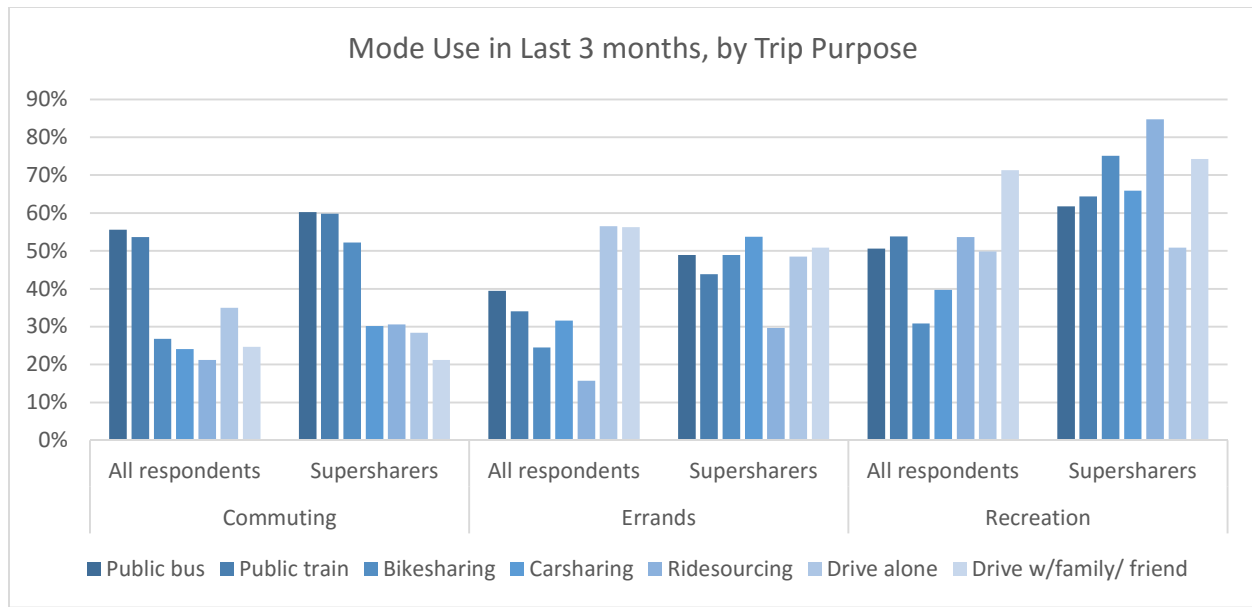


Figure 4: Mode use in last 3 months, by trip purpose--supersharers v. all respondents⁷

Transit forms the backbone of all respondents' mobility picture, but the heaviest shared-mode users are also heavier transit users. For every trip type, a 5 to 10% greater proportion of supersharers report using transit compared with the overall group.

- **Commute trips.** For their commutes, both groups most frequently cited transit modes; but more than half of supersharers also said they had used bikesharing.
- **Errands.** For running errands, the overall group tends to turn to personal vehicles, distantly followed by transit and shared modes. Supersharers are most likely to use carsharing. Ridesourcing was the least-used mode for errands in both groups.
- **Recreational trips.** For recreational trips, supersharers report use of *every* mode (including driving) in proportions greater than the overall group. Especially notable are the very high proportions of supersharers who made recreational trips using ridesourcing, bikesharing, or carsharing, percentages that far outweigh those of the overall group (by more than double in the case of bikesharing). The wider variety of modes used for recreation versus commuting likely reflects the greater variety of destinations for social events, at times and places where transit coverage is not necessarily reliable.

Broadly speaking, these responses suggest that the supersharers take advantage of the whole menu of mobility choices, readily switching to the mode that makes the most sense for a given trip and purpose.

⁷ Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

People who use transit and shared modes report lower car ownership and less driving, as well as increased physical activity and decreased transportation spending

People who take greater advantage of shared modes report lower household vehicle ownership and decreased spending on transportation.

Compared to people who haven't used any shared modes beyond transit, respondents who are experienced with new forms of shared mobility report owning nearly half a car less—1.5 versus 1.05 vehicles per household (Figure 5). Vehicle ownership is even lower among supersharers, who report 0.72 cars per household. By comparison, the average ownership rate across the seven study regions is 1.72 vehicles per household. Though it's not possible to discern cause and effect in these responses, if these ownership differences are indeed attributable to the early-adopting supersharers' selecting from a larger menu of mobility options, these findings suggest a promising path to vehicle ownership reductions and associated benefits from reduced solo car travel if these lifestyle choices become more broadly dispersed. Increasing the breadth of shared mobility options and broadening access for more neighborhoods and communities could help cities meet goals to reduce single occupancy driving.

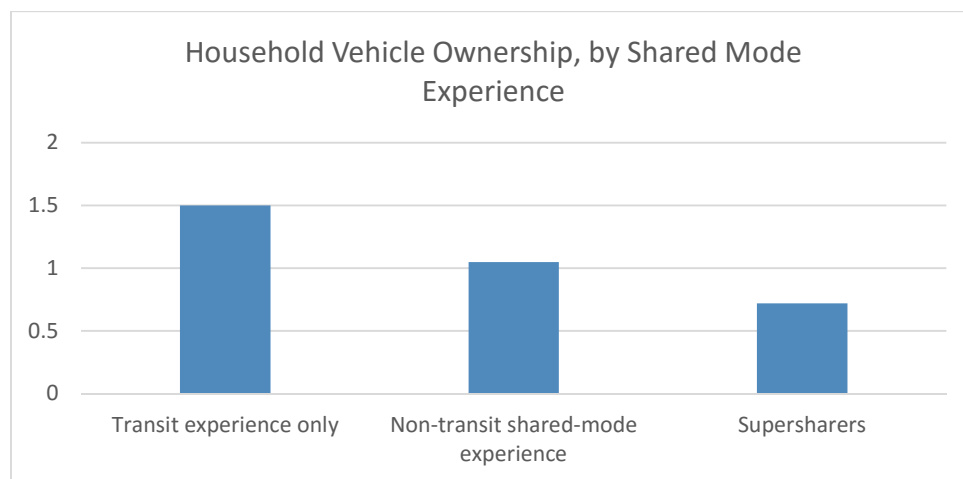


Figure 5: Household vehicle ownership, by shared-mode experience⁸

Lifestyle changes since beginning to use shared modes are notable across both groups, with a net movement away from trips by personal automobile and toward greater use of transit. Note that these responses represent qualitative results—the survey did not gather information on the magnitude of behavior or lifestyle changes for individual users. In all, 31% of general shared mobility users and 33% of supersharers drove a car to work less often; 22% and 26%, respectively, drove less for errands and recreation; and 43% and 42% said they used public transit more, versus 28% and 32% who said they

⁸ Q19: "How many cars does your household own or lease?" Crosstabbed on Q1: "Have you ever used a shared form of transportation like bike-sharing, car-sharing, or a ridesharing service like Uber or Lyft?" and Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

used transit less (Figure 6).⁹ More than half of all respondents and nearly two-thirds of supersharers say they are more physically active since they began using shared modes. Small numbers of respondents in both groups (around 4% for commuting and 10% for errands) said that they drove more since beginning to use shared modes. Without knowing more about the individual situations, it's unclear what the reasons are for such a change, or what the magnitude of the change is. Because errands are the trip type with greater increased driving, it is possible this reflects users who begin turning to carsharing to access destinations they were previously unable to reach, or for which they previously used a non-auto mode. Also, some percentage of people will simply move to a location, take a job, or enter a phase of life that requires more driving, despite their desires or previous behavior.

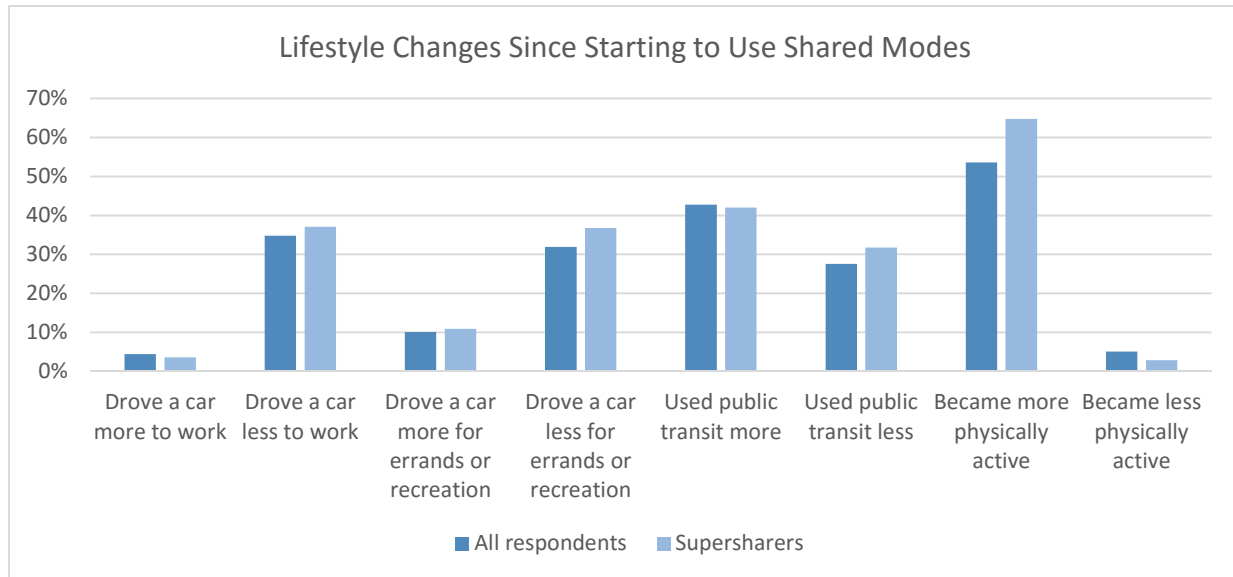


Figure 6: Lifestyle changes since starting to use shared modes—supersharers v. all respondents¹⁰

When asked about changes to their household and finances since starting to use shared modes (Figure 7), respondents across the board reported shedding vehicles and reducing expenses, though supersharers reported greater benefits. In the overall group, 20% reported postponing a car purchase, 18% had decided not to purchase, and 21% sold a car and didn't replace it, while 8% had acquired a new vehicle for personal use. A net of 18% spent less on transportation.¹¹

⁹ These figures represent the net difference between users who reported less driving and those who reported more. Breaking the groups out individually, 35% of general shared mobility users reported driving to work less often versus 4% who reported driving more; 37% of supersharers drove a car to work less often, versus 4% who said they drove more. For errands and recreation, 32% of the wider group and 37% of supersharers, respectively, drove less for errands and recreation, versus 10% and 11% who drove more. 43% and 42% said they used public transit more, versus 28% and 32% who said they used transit less.

¹⁰ Q10: "Have you made or noticed any of these changes in your transportation habits since you started using shared forms of transportation?" Crosstabbed on Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

¹¹ The text reports net figures for change in transportation spending. The underlying percentages are as follows: Among all respondents, 45% reported spending less, while 27 reported spending more. Among supersharers, 52% reported spending less, 22% spending more.

Shared Mobility and the Transformation of Public Transit

Among supersharers, 21% postponed buying a car, 22% had decided not to buy, and 27% had sold a car and didn't replace it, while 5% had bought a new car. A net of 30% of supersharers decreased transportation spending.

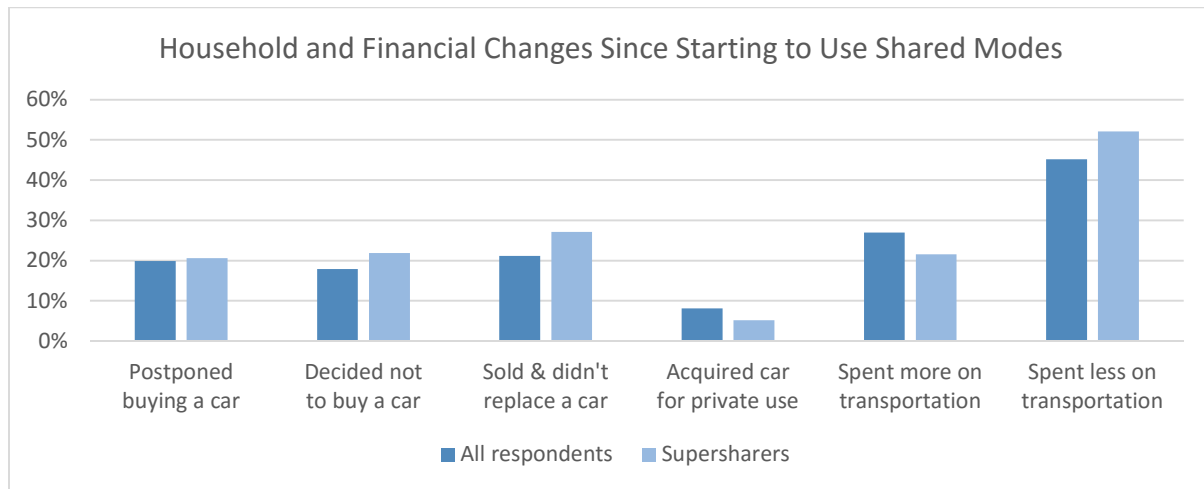


Figure 7: Household and financial changes since starting to use shared modes—supersharers v. all respondents¹²

¹² Q11: "Have you or your household made any of these financial changes since you started using shared forms of transportation?" Crosstabbed on Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

2: Shared Mode and Transit Usage Patterns

Shared modes largely complement public transit, enhancing urban mobility. However, they may compete with transit on some routes and at certain times of day. Ridesourcing services are most frequently used for social trips between 10 p.m. and 4 a.m., times when transit runs infrequently or is unavailable. Bikesharing plays a peak hour role in augmenting transit systems, while carsharing is mostly used off peak. The car-based shared modes likely substitute more for taxi or automobile trips than transit trips. Transit is most competitive when it travels in its own right of way and provides frequent service.

The interviews, survey, and data analysis conducted for this study together suggest that public transit and shared modes complement one another by serving different trip types and making car-free or car-light lifestyles feasible for more people. Different shared modes seem to be filling specific niches in the mobility ecosystem, with ridesourcing used most frequently for social trips, late at night, and when alcohol is a factor; carsharing used for errands and off-peak trips to areas without good transit access; and bikesharing providing last-mile connections and acting as a pressure valve for crowded transit systems during peak hours.

In interviews, transit system officials tended to view new forms of shared mobility as largely complementary to their core mission, though they are carefully watching for signs of whether new, tech-enabled modes will change how riders use transit. Many parties pointed to the complexity surrounding access to a constrained public way (particularly parking spots and curb access) as an area that will increasingly require negotiation and policy attention as shared modes grow.

Representatives of cities with robust public transit systems interviewed for the study had the least concern about the impact of new modes on their transit services, and were often already engaged in established relationships with bikesharing and carsharing operators. Transit agencies with more dispersed ridership, fewer fixed guideway routes, or a higher proportion of paratransit rides or other expensive operations tended to be the most interested in possibilities for new complementary mobility options and service models. However, some transit agencies expressed concerns regarding the potential impact of ridesourcing on their existing service, and several local regulators addressed tactics by ridesourcing operators—such as commencing operations in a jurisdiction before regulatory authorization was obtained—that they believed made collaboration more politically complicated.

Ridesourcing is most commonly used for recreation and social trips, late at night, and often when alcohol is involved

Survey responses suggested that ridesourcing is a common part of the mobility menu for many people. However, it is used far more for socializing than for other kinds of trips. More than half of respondents (54%) indicated that they had used ridesourcing for a recreational or social trip within the last three

months (Figure 8). Only 21% said they had used it to commute, and 16% reported using it for shopping or errands. In fact, for recreational and social trips, ridesourcing was the single top shared-use mode.

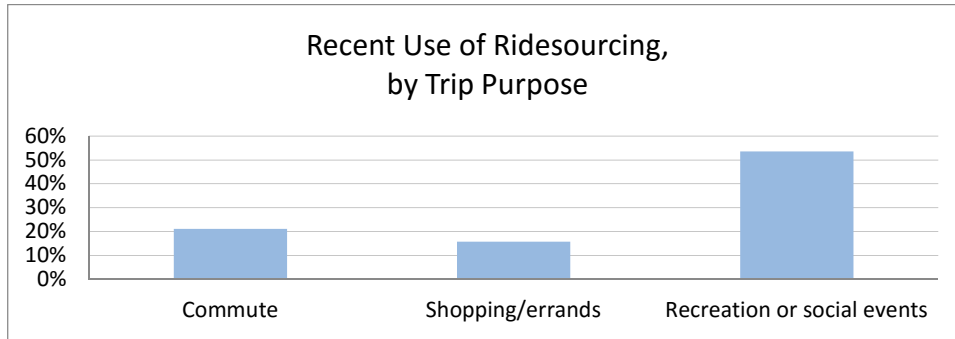


Figure 8: Recent use of ridesourcing, by trip purpose¹³

Asked about the hours of the day and times of week that they most commonly use various modes (Figure 9), survey respondents cited ridesourcing as the least frequent choice during the morning rush, evening rush, and mid-day, as well as weekdays overall. However, in the evening and late at night, ridesourcing was by far the top choice.

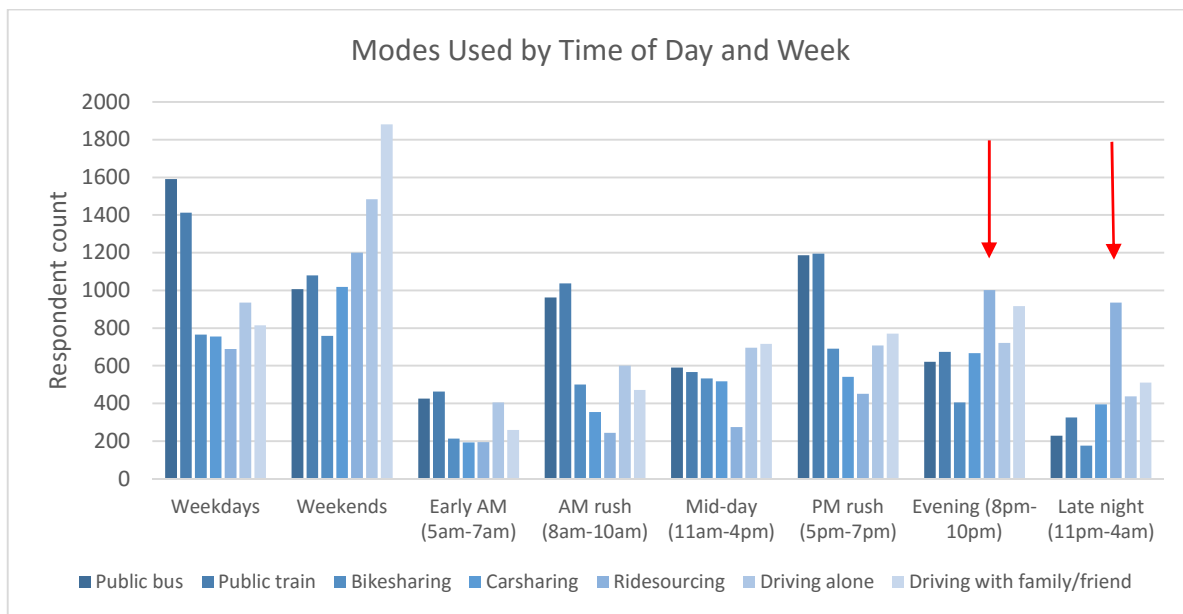


Figure 9: Mode preference by time of day and week. Ridesourcing is the most frequent choice in the Evening and Late Night periods, while it is the least frequent choice at all other times of day and on weekdays.¹⁴

The survey findings are bolstered by an analysis of ridesourcing wait time and demand (as reflected in the average surge multiplier applied to base fares) throughout the week and around the clock (Figure 10). In every study city, a clear peak in ridesourcing demand is visible at some point between 10 p.m. and 4 a.m. on weekends, and in the majority of cities this is the time of greatest demand overall. It is

¹³ Q9: "In the past 3 months, which of the following forms of transportation have you used for each type of trip?"

¹⁴ Q14: "At what hours of the day and week do you generally use each form of transportation?"

also the time of the day and week when scheduled transit capacity is at its lowest point and average headways are longest. (See Appendix E for more detail on this analysis.)

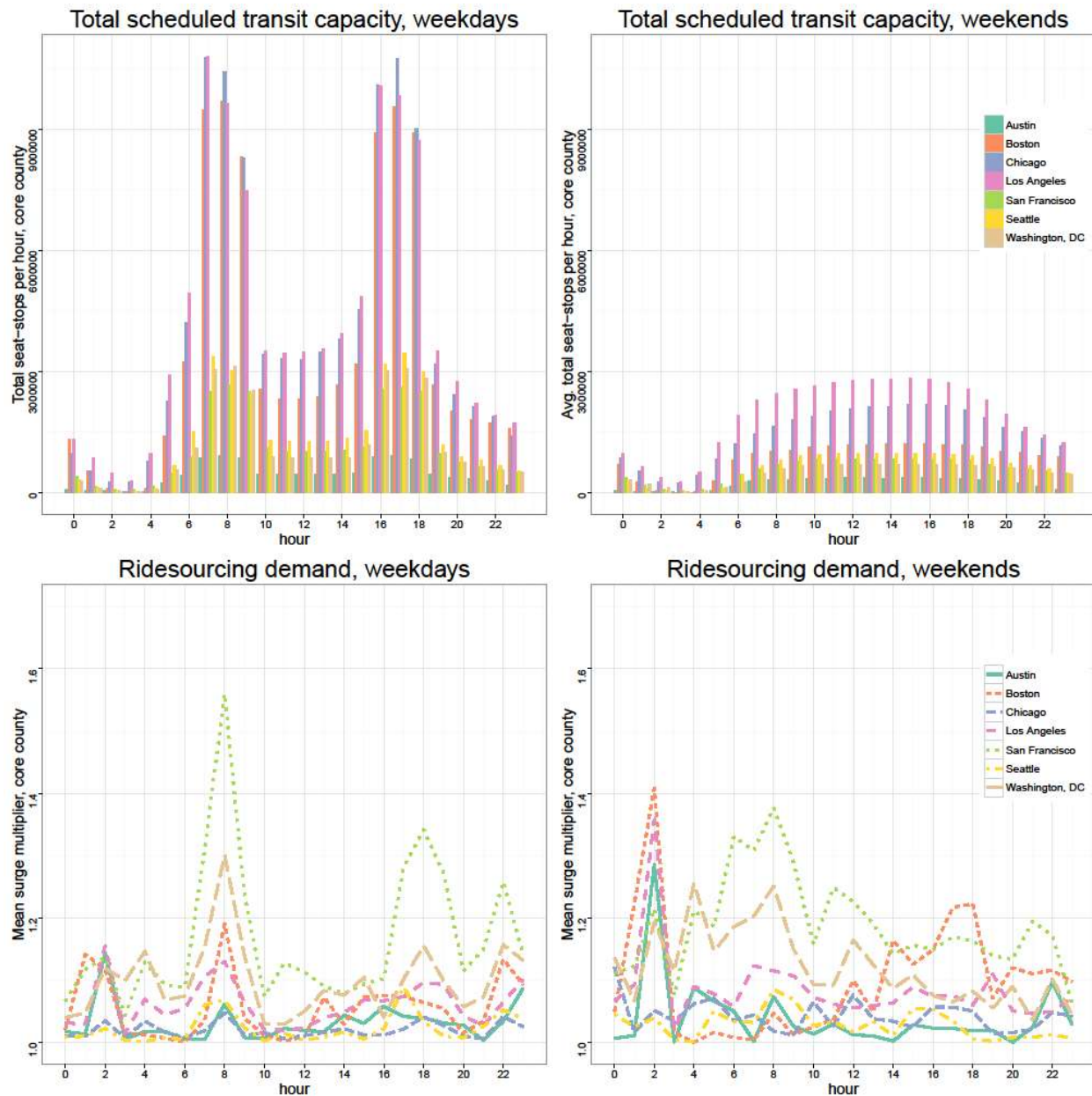


Figure 10: Scheduled transit capacity (top) and typical ridesourcing demand (bottom) by hour, for weekdays and weekends. The x-axis in each chart corresponds to the hours in a 24-hour day (all times local), the y-axis the relevant metrics aggregated across each study region.

Additionally, the New York City Taxi and Limousine Commission has released its own summary counts of ridesourcing service levels for several time periods, which further support these findings. Limited only to Brooklyn (since Manhattan's transportation picture is unique in North America in so many respects) these actual passenger counts follow the same patterns, with the highest use taking place late at night during the weekends, with a smaller peak during the weekday morning rush.

An analysis of the travel time by transit and ridesourcing (later in this section) systematically explores the tradeoffs that underlie the late-night preference for these services.

People turn to ridesourcing when they're drinking

The survey contained no questions specifically about alcohol use, but it did inquire into factors influencing transportation choices, allowing for open-ended answers. Unprompted, more than 100 respondents volunteered that alcohol consumption was a major consideration in their mode choice for recreational trips, and a number named ridesourcing or a specific ridesourcing provider as their preferred choice in that case. It is likely that if alcohol use had been among the explicit answer choices, the number would have been higher.

Relatively few people use ridesourcing to commute—and those who do, do so occasionally

Some people do use ridesourcing to get to and from work at least some of the time. Figure 10, which shows clear demand peaks during weekday rush hours, bears this out. However, it is not a major part of the mobility picture for the majority of commuters who responded to the survey.

Among the 21% of respondents who did report using ridesourcing to commute (broken out in Figure 11), 38% said that their most recent ride on a bus or a train was today or yesterday, while about one-quarter of the group (or about 5% of total respondents) said they last used ridesourcing today or yesterday.

The proportion declines to 18% for transit for trips within the last week, while increasing to 37% for ridesourcing. Together, this suggests that people use ridesourcing situationally, and generally not daily—as a mode that fills in gaps or works under specific circumstances rather than as the core of their commute. This is similarly reflected in the frequency of use: even among respondents who report ridesourcing as their top shared mode, only 7% say they use ridesourcing daily, while 43% report using it 1–3 times per month (Figure B-2 in Appendix B contains a full breakout of frequency by mode).

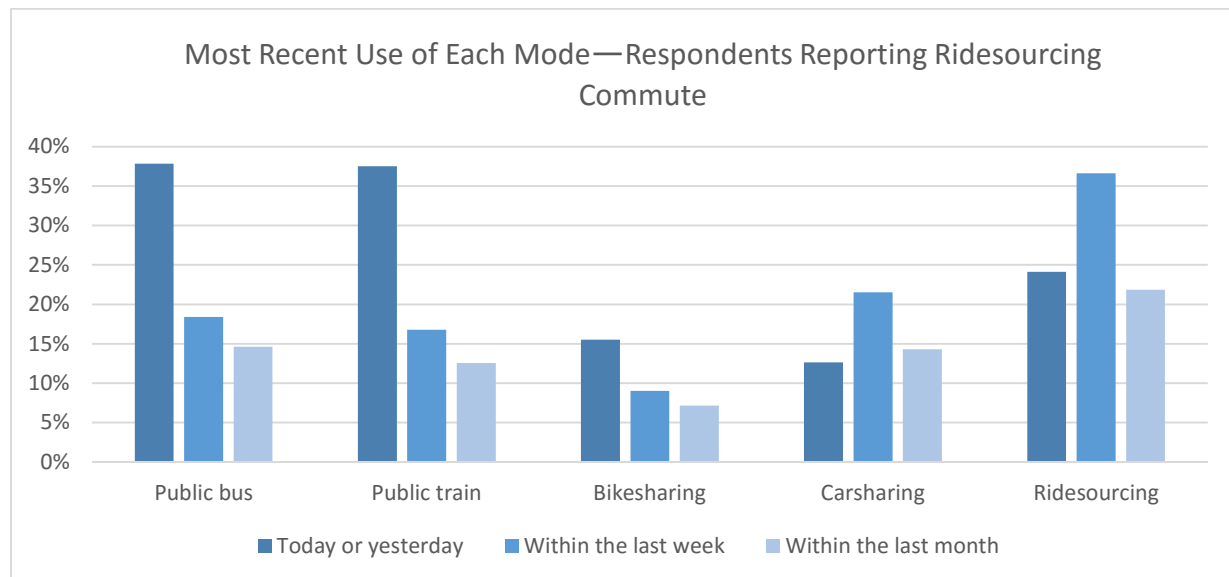


Figure 11: Most recent use of each mode—respondents reporting recent ridesourcing commute¹⁵

¹⁵ Q3: “When was the LAST time you used each form of transportation? (Please choose the most recent period when you used each type.)” Crosstabbed on Q9: “In the past 3 months, which of the following forms of transportation have you used for each type of trip?”

Among shared modes, bikesharing has a role more like transit, while carsharing and ridesourcing are more like personal automobiles

In listing alternatives if their preferred mode was not available, respondents seem to cluster into two groups: active, transit-centered lifestyles, and auto-centered ones, which feature lower initial levels of transit use (Figure 12).

Bikesharing seems to be very much a part of the active lifestyle cluster, with 50% reporting that they would ride a bus or train if bikesharing were not available, and another 39% saying they would walk or ride their own bike; only 7% would drive or use ridesourcing. This underscores bikesharing's role as an extension of the transit system—though it could also be seen as evidence of bikesharing diverting some trips from transit, a phenomenon that has been evaluated in several cities by Martin and Shaheen (2014)¹⁶.

Carsharing and ridesourcing users are more auto-centered, with about a third of those modes' top users reporting they would drive alone or with a friend if their preferred mode was not available. Pointing to the level of crossover between modes, 15% of carsharers would use ridesourcing, and 25% of ridesourcers would use carsharing. Both are lighter transit users: 23% of carsharers and 15% of ridesourcers would ride a bus or train instead. Some 8% of ridesourcing users say they'd use another mode entirely, and all but one of these open-ended responses mentioned using taxicabs.

Together, these findings suggest two things: 1) unlike bikesharing, those who prefer ridesourcing and carsharing are largely not substituting for transit trips, but rather for private auto trips or taxi rides, and 2) people who prefer carsharing and ridesourcing are probably more likely to have access to a car, and these shared modes give them a way to leave that car at home more often. A number of studies have established that carsharing users are likely to shed personal vehicles, and these results point to the possibility of a similar effect for ridesourcing. More research is needed to understand the net effects of these substitutions.

¹⁶ Martin, Elliot, and Susan Shaheen. "Evaluating Public Transit Modal Shift Dynamics in Response to Bikesharing: A Tale of Two US Cities." *J. Transport Geography* 41 (2014) 315-324.
<http://dx.doi.org/10.1016/j.jtrangeo.2014.06.026>

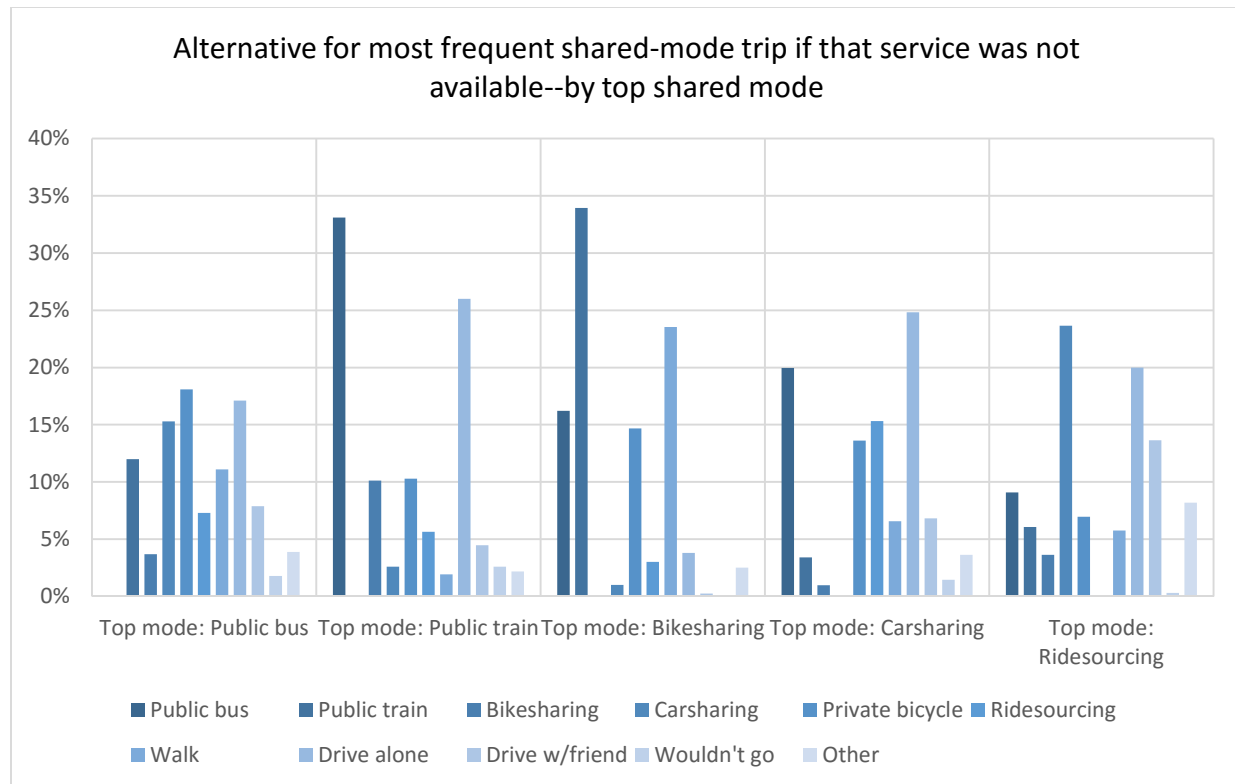


Figure 12: Alternative for most frequent shared-mode trip if that service was not available--by top shared mode¹⁷

The table of frequency of use by mode (Figures B-2, Appendix B) further points to these same lifestyle clusters. Those who name carsharing and ridesourcing as top modes report frequent driving, both alone and with friends or family, at almost twice the rate of those who named bikesharing, bus, or train as their top mode.

Top carsharers and ridesourcers also name bikesharing as their least frequently used mode, with nearly 80% and 70%, respectively, saying they use it less than once a year, or never.

Ridesourcing and transit travel time tradeoffs: Transit is more competitive when it travels in a dedicated right of way or is otherwise not subject to traffic congestion

Trip length and speed may be a key concern in decisions about which mode to use, with faster modes increasingly preferable as trips get longer. While the survey did not ask specifically about the distance of particular trip types, it did ask about typical trip lengths by mode. Among respondents who named ridesourcing as top mode and who had a ridesourcing commute, 58% reported their most frequent ridesourcing trip was under 5 miles, while 65% reported their most frequent train ride was over 5 miles.

Asked about the length of their most frequent one-way trips on various modes (Figure 13), respondents took the longest trips when driving, averaging around 12 miles both alone or with a friend, followed by public train at 9.6 miles. Carsharing and ridesourcing were used for somewhat shorter trips (8.5 and 6.6

¹⁷ Q5: "Thinking about the service you selected in the prior question, how would you make your most frequent trip if that service was not available?" Crosstabbed on Q4: "Which shared-use service do you use most often?"

miles, respectively), but still for longer trips than the typical bus ride of around 5 miles. Bikesharing was used for the shortest trips, at just over 3 miles.

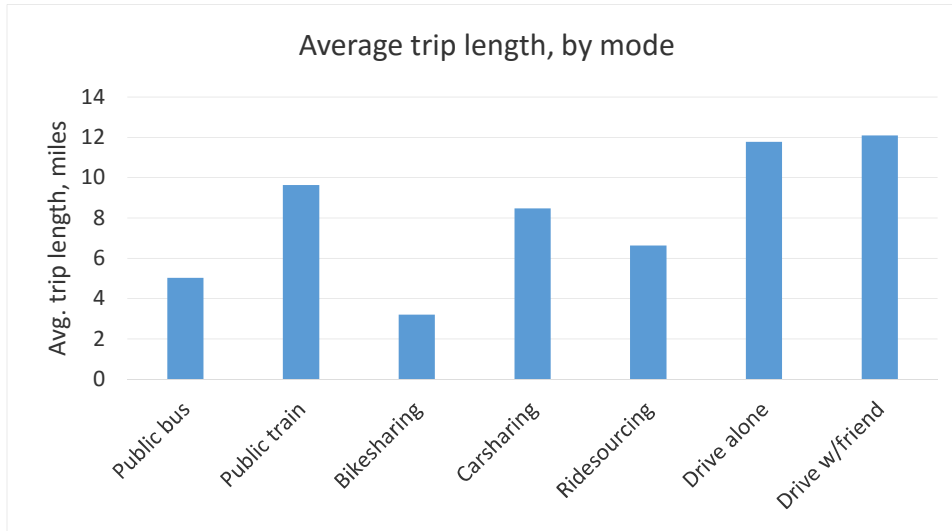


Figure 13: Average trip length, by mode¹⁸

To create a broad picture of the time tradeoffs for various trips, and to reveal areas where transit has a particular advantage or disadvantage, the researchers systematically queried a Google trip planning tool to produce a grid of the comparative travel times for transit and for ridesourcing at points across the whole of each study region. Times are calculated for trips from a single origin point—located in the highest employment census block group in the region’s core county—to every other point in the region, along a half-mile grid. The figures below show the ratio between travel time by scheduled transit and by ridesourcing, including typical wait times and traffic for both modes.¹⁹ (See Appendix D for methodology of this approach and for maps of all seven regions.)

The comparative travel time analyses for transit and for ridesourcing were performed with all trips originating in the census block group with each region’s highest job count. A more comprehensive analysis would create comparisons for a number of origins—including residential areas, nightlife districts, and large commercial nodes—beyond the business district that is generally the focus of regional transit. This wider analysis is beyond the scope of the present study because of the time it takes to compile queries and generate the maps, but the analytical approach is readily adaptable to such comparisons, and a second phase of this research will include further analysis along these lines.

A comparison of the travel time for the same trip on both transit and ridesourcing underscores the rational basis for the usage patterns suggested by the survey and demand analysis. For many trips,

¹⁸ Q8: “If you use them, about how long is your most frequent one-way trip on each form of transportation?”

¹⁹ A peak-hour trip that takes 20 minutes by transit and 40 minutes by ridesourcing would have a ratio of 0.5 ($20 / 40 = 0.5$). A trip that takes 40 minutes on transit and 20 minutes by ridesourcing would have a ratio of 2.0 ($40 / 20 = 2.0$). A ratio below 1.0 (green points) means that transit is the faster mode for a trip between the origin and that point; ratios between 1.0 and 1.5 (yellow points) are essentially a wash in time terms, where it seems likely that cost would play a greater role in the choice; ratios above 1.5 (orange and red points) mean that ridesourcing is clearly the faster choice. No ratio is calculated for destination points for which there is simply no transit route from the origin (black points on gray background).

transit is a much faster choice at rush hour, especially along fixed-guideway corridors. Alternatively, the trips may be close enough in duration that the significant difference in cost would make a ridesourcing trip prohibitively expensive for daily rides, though it might make sense situationally. But when traffic congestion is less of a factor, and transit headways are much longer, transit's time advantage is much more contained. In addition, some areas or corridors might have unusually long transit times because of the need for multiple transfers even to go a relatively short distance; these areas might be places where specific transit improvements, such as new express service or the implementation of bus rapid transit, could have an outsized impact for riders.

In Chicago (Figure 14), the region's strong transit service, much of which travels in dedicated rights of way, along with significant traffic congestion, combine to create a map showing large swathes where transit has the advantage or is roughly equivalent to ridesourcing for peak hour trips from the central business district (Figure 14, left map). Especially along CTA and Metra lines, transit's time advantage can stretch far beyond the city limits in specific corridors. Conversely, several suburban Cook County areas that lie between the region's radial transit lines show a time advantage for ridesourcing, even with typical peak-hour congestion taken into account. However, these points are so far removed from the downtown origin that most people making that trip regularly would far more likely be driving themselves. These are areas where last-mile shared mobility efforts might be fruitful. Many outlying areas (20 or more miles from the Loop business district) simply have no coverage by scheduled transit, and are so far from regional transit lines that driving is currently the most logical choice for trips downtown.

At midnight, however, the picture shifts considerably (Figure 14, right map), and only a limited area close to downtown remains more quickly served by transit. In much more of the city, along with the entirety of suburban Cook County, the time advantage of ridesourcing is considerable. For late-shift workers or people returning from a night out, the choice would likely come down to the ability to access or afford the ridesourcing trip. As the demand and survey data show, this is a time when many people decide to pull out their mobile phones.

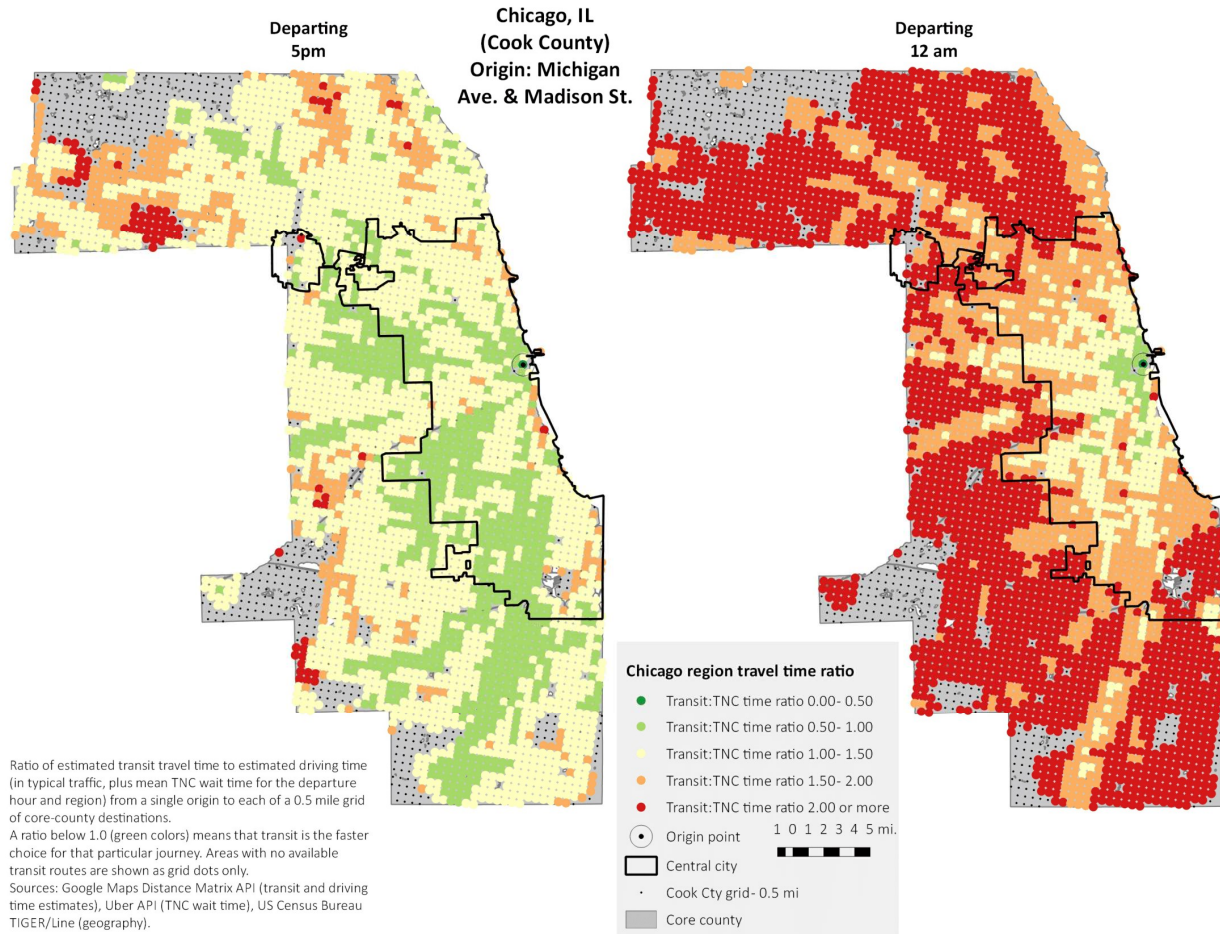


Figure 14: Travel time ratio, 5pm and midnight, Chicago region. Ratio of estimated transit travel time to estimated driving time (in typical traffic, plus mean TNC wait time for the departure hour and region) from a single origin to each of a 0.5 mile grid of core-county destinations. A ratio below 1.0 (green colors) means that transit is the faster choice for that particular journey. Areas with no available scheduled transit routes are shown as grid dots only. Sources: Google Maps Distance Matrix API (transit and driving time estimates), Uber API (TNC wait time), US Census Bureau TIGER/Line (geography).

The picture is different in regions that have grown around the private automobile and have made less investment in transit that can move past traffic. In Austin, where dedicated-guideway transit is a small portion of the transit system and buses are in mixed traffic and congestion for much of the day, transit is the faster way out of the central business district for fewer destinations (Figure 15). For much of the core city and the greater part of the region, there are no transit routes available from downtown. Congestion's role in limiting transit accessibility in Austin is underscored by the expansion of transit's time advantage at midnight on a few central-city corridors—which points to the potential for transit in a separated right-of-way to improve transit modes' competitiveness, especially in the congested corridors that are covering more of the region. Overall, however, ridesourcing is currently the faster of the two modes from downtown for the vast majority of Austin destinations, regardless of the time of day.

Shared Mobility and the Transformation of Public Transit

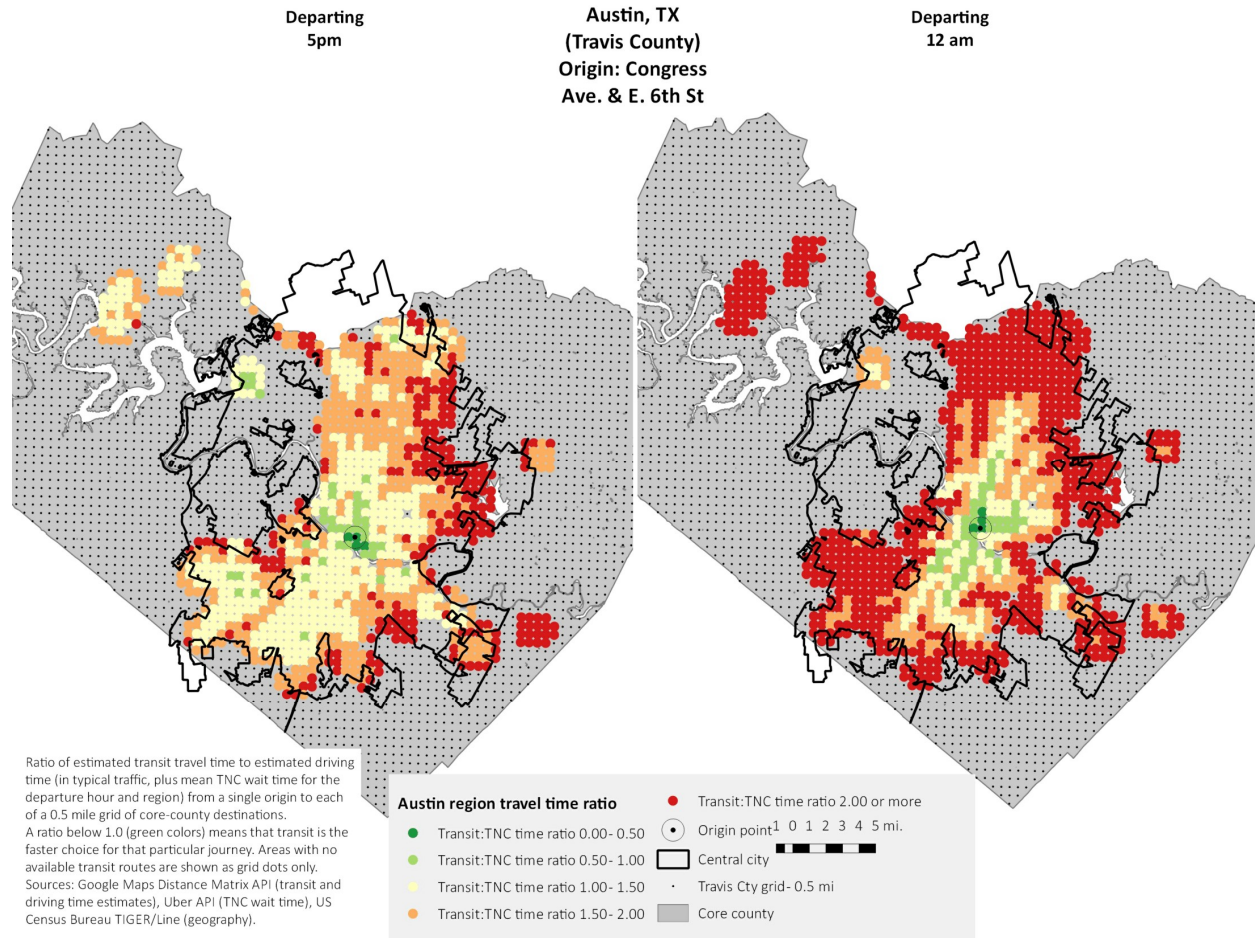


Figure 15: Travel time ratio, 5pm and midnight, Austin region. Ratio of estimated transit travel time to estimated driving time (in typical traffic, plus mean TNC wait time for the departure hour and region) from a single origin to each of a 0.5 mile grid of core-county destinations. A ratio below 1.0 (green colors) means that transit is the faster choice for that particular journey. Areas with no available scheduled transit routes are shown as grid dots only. Sources: Google Maps Distance Matrix API (transit and driving time estimates), Uber API (TNC wait time), US Census Bureau TIGER/Line (geography).

3: Equity in an Expanding Mobility Marketplace

Because shared modes are expected to continue growing in significance, public entities should identify opportunities to engage with them to ensure that benefits are widely and equitably shared. Transit agencies can improve urban mobility for the entire spectrum of users through collaboration and public-private partnerships, including greater integration of service, information, and payment methods.

Everyone can benefit from a transportation system that provides more mobility options through seamless transfers, integrated fare payment methods, and improved information. However, such a system is only possible if public-sector entities make a concerted effort to ensure that collaboration with private mobility providers results in services that work for people of all ages, incomes and mobility needs.

Potential for partnerships and collaboration to equitably expand mobility access

As the shared mobility industry continues to grow and evolve, many public-sector representatives said in interviews they look forward to increased collaboration with the private sector. For instance:

- A number of transportation agencies are already partnering with new shared mobility providers. The earliest collaborations were with vanpooling, carsharing, and bikesharing providers, but partnerships increasingly include ridesourcing companies and experiments with microtransit and other forms of dynamic demand response.
- Regulation of ridesourcing providers remains a contentious process. At the same time, transit agencies recognize ridesourcing as part of the new urban fabric and an opportunity to extend and expand the use of transit, such as through increased first/last mile connections.
- Transit agencies are happy to let private providers lead in developing customer-facing technologies, and are widely committed to providing the open data that helps make this possible.

Because most partnerships between ridesourcing providers and transit agencies are still in the very early stages, however, there is little empirical record at this point upon which to assess their impact or value. A number of the existing forms of partnership and collaboration are outlined in the Business Models section of this report.

In reconciling collaborative opportunities with their mandates to serve the public interest, transit agencies and other public entities should recognize their role as conveners and gatekeepers to the public way. The same institutional heft that makes transit agencies attractive partners for the private sector also allows them to set the terms of agreement to ensure all users have equitable access to information resources, streamlined payment options, and improved, integrated mobility services.

Keeping technology-enabled service innovations fair and accessible

Because it's a precondition to using many shared mobility services, access to information technology, and smartphones in particular, has been pointed to as a barrier to widespread adoption of new shared modes, especially among lower-income people, the elderly, and those who are less comfortable using new technology.

The survey found that—while there are some differences among the particular tools that various groups of respondents prefer for accessing information about transit and other mobility options—transit information technologies are widely used across income and experience levels. (These findings must be approached with the knowledge that the survey was administered online, so it is biased to an unknown degree towards users with some level of familiarity with the internet.)

Comparing respondents with only transit experience to those who have used new shared modes (Figure 16) shows both groups are broadly similar in their familiarity with transit-related information technologies. The most notable difference is in the provider of the tools—the transit-only group was much more likely to use transit-agency provided applications or websites, as opposed to the third-party tools preferred by respondents who have used other shared modes.

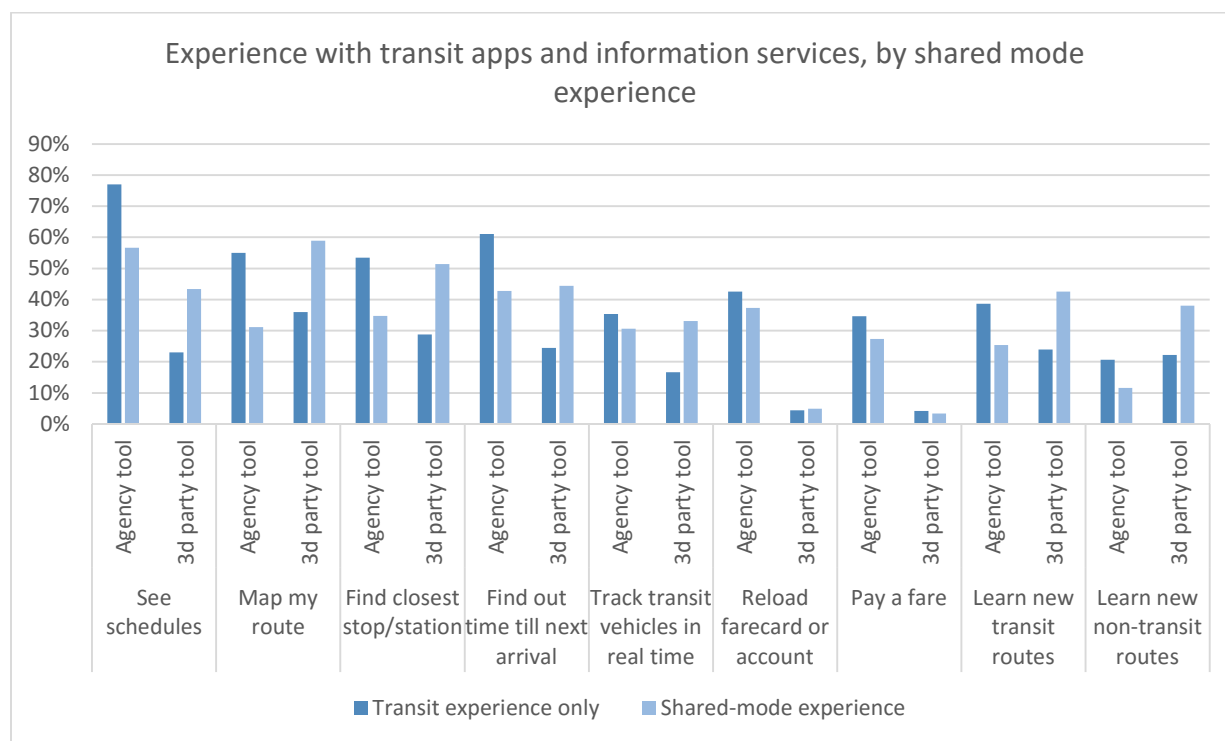


Figure 16: Experience with transit apps and information services, by shared mode experience²⁰

Looking at differences across income levels (Figure 17), the survey found little difference in overall access. There were nearly uniform levels of experience (around 70%) across income groups when it

²⁰ Q15: "Many websites or apps show information about public transit schedules and operations? Which of the following activities have you performed for trips in the metro area where you live?" Crosstabbed on Q1: "Have you ever used a shared form of transportation like bike-sharing, car-sharing, or a ride-sharing service like Uber or Lyft?"

came to using transit agency-provided apps or websites to view schedules, while use of third-party tools increased with income.

Even among the lowest income group, however, around half of respondents had used third-party informational apps, compared with around 70% among the highest-use groups. The difference in adoption rates of transit agency-provided tools vs. third-party tools points to the ongoing value of customer-facing technologies in which transit agencies have invested, especially for users who might not have the most current hardware.

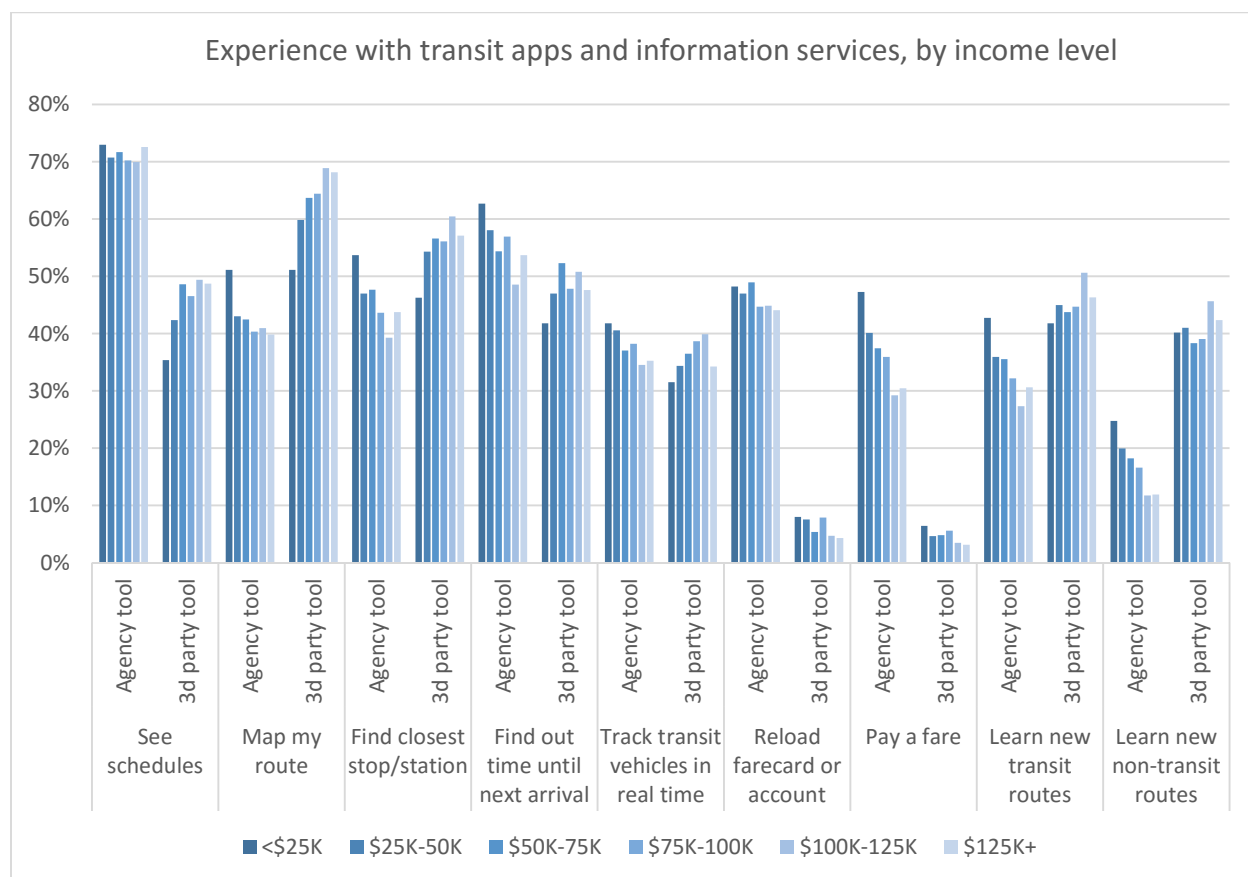


Figure 17: Experience with transit applications and information services, by income level²¹

Since many shared-use services involve using a proprietary mobile application, it follows that use of third-party tools would grow with shared-mode usage in general. Taken together, these findings suggest that increasing access to shared-use mobility has the potential to improve the transportation picture for people with the fewest options—improving connections to transit and access to the region as a whole. Lack of information remains a significant barrier, but lack of access to technology is decreasing over time.

²¹ Q15: “Many websites or apps show information about public transit schedules and operations? Which of the following activities have you performed for trips in the metro area where you live?” Crosstabbed on Q22: “What was your total household income last year?”

Equity implications and other complexities of fare and service integration

Transit agencies across the country are working to migrate to new electronic fare payment systems. The integration of fare payment and service information is central to innovations in public transit, the emerging mobility models, and the trend towards mobile application-based payment in general. Even if this involves no change to the actual fare structure, many transit agencies will need to assess the impact of these changes on minority and low-income customers as part of their obligations under Title VI of the Civil Rights Act of 1964.

Based on the lessons of Title VI equity analyses performed during recent fare media transitions by the Chicago Transit Authority²² and Portland's TriMet,²³ transit agencies will need to maintain the ability for unbanked customers to purchase fares using cash or other means that do not require a bank account or credit card. Moreover, transit agencies will need to assess whether proposed changes unduly burden disadvantaged communities in several other dimensions, including:

- New non-fare fee structures
- Fare loading levels
- Changes to the mix of retail outlets for fares and fare media, including purchase by mail
- Access for persons with limited English proficiency
- Registration requirements

Because they have fewer Title VI reporting requirements, demand responsive services have more flexibility to change and experiment with new fare structures. As a result, this is an area where many innovations are likely to be initially located. The flipside of this flexibility is that reservations and fare payment for demand responsive service that is adjacent to a fixed route transit system (such as a microtransit or ridesourcing provider feeding a larger fixed-route system) might have to remain on a separate payment and reservation platform pending the main transit system's Title VI-compliant adoption of fare changes. So, while this flexibility can help encourage innovative new models in the demand responsive services (for fare payment, customer interaction, or actual delivery of mobility services), full fare integration will always be subject to Title VI obligations when it is rolled out to the entire fixed route system.

Unrelated to Title VI but still central to the discussion of fare integration is the issue of federal transit benefit programs, under which pre-tax money can be used for payment of transit fares and certain other forms of commuter transportation. Under present IRS rules, however, pre-tax dollars cannot be used for carsharing, taxis, ridesourcing, or bikesharing. Thus any cross-modal fare integration requires the ability to discriminate between modes' benefit eligibility, and to pull from separate payment purses accordingly.

Differing use patterns across incomes

Public transit is the mode of choice for every income level

While the survey found differences in how households access the transportation system depending on

²²

http://www.transitchicago.com/assets/1/miscellaneous_documents/Open_Standards_Fare_System_Equity_Analysis.pdf

²³ <https://trimet.org/pdfs/equity/2016-fare-equity-analysis>

their income, everybody had one thing in common: transit is by far the top shared-use mode at every income level (Figure 18). The lowest income riders are most likely to take the bus, while riders are increasingly likely to use the train as income level rises. This may, in part, reflect differences in the geographic availability of bus and train services, especially in the study cities. Among non-transit shared modes, carsharing is evenly popular across income levels, while bikesharing becomes more popular at higher household income levels.

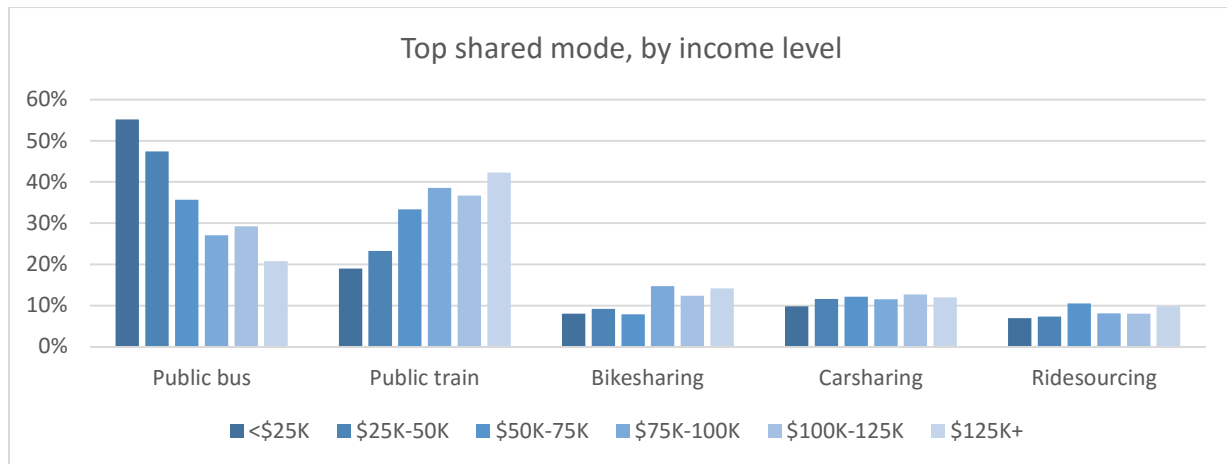


Figure 18: Top shared-use mode, by income level²⁴

Similar patterns emerge when looking at frequent (at least weekly) use across all modes, split by income level (Figure 19). Bus ridership falls by half as income increases, while solo driving roughly doubles between the lowest and highest income levels. In terms of frequent use, carsharing is more used at the lower end of the income scale, while the opposite is true of bikesharing.

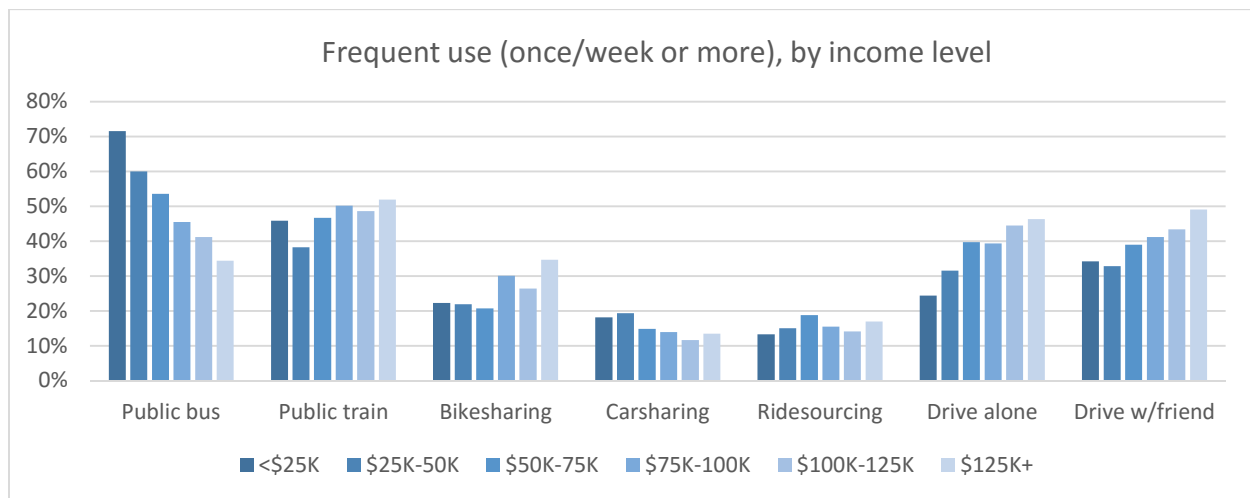


Figure 19: Frequent use (once/week or more) by income level²⁵

²⁴ Q4: "Which shared-use service do you use most often?" Crosstabbed on Q22: "What was your total household income last year?"

²⁵ Q7: "How often do you travel in each of these ways?" Crosstabbed on Q22: "What was your total household income last year?"

Lower-income households have much to gain from wider availability of shared-use modes, and carsharing in particular.

Shared-use modes expand options for lower income households. As noted before, the option to drive rises with income, and at three times the rate of every other cohort, the lowest-income group reports that if their top mode was not available, they simply wouldn't go (Figure 20).

Among non-transit shared modes, carsharing was the top alternative mode for low- to moderate-income respondents, with its use decreasing at higher incomes. This underscores the role that carsharing in particular can play in helping people access destinations more easily reachable by car, while avoiding the costs of full-time car ownership.

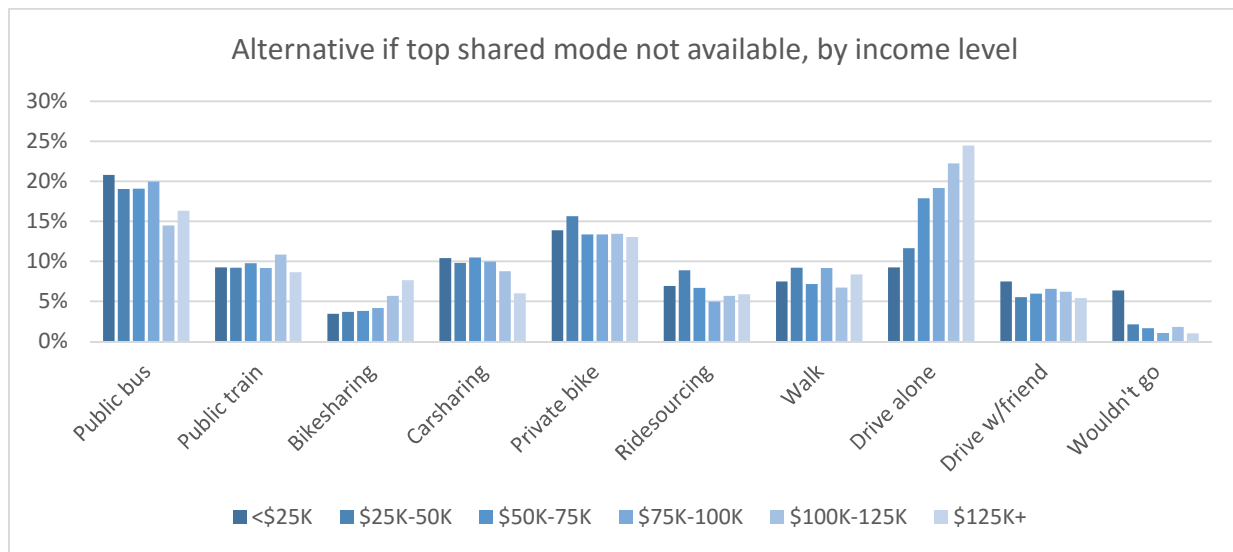


Figure 20: Alternative if top shared mode not available, by income level²⁶

²⁶ Q5: "Thinking about the service you selected in the prior question, how would you make your most frequent trip if that service was not available?" Crosstabbed on Q22: "What was your total household income last year?"

4: Public-Private Collaborations around Paratransit

The public sector and private mobility operators are eager to collaborate to improve paratransit using emerging approaches and technology. While a number of regulatory and institutional hurdles complicate partnerships in this area, technology and business models from the shared mobility industry can help lower costs, increase service availability, and improve rider experience.

Paratransit and other community transportation services—which often take the form of subsidized door-to-door trips in wheelchair-accessible shuttles and taxis—play a vital role in serving older adults and persons whose disabilities prevent them from readily accessing traditional public transit. These services are highly regulated and expensive to operate, and both demand and costs are rising steeply. A recent FTA study found that between 1999 and 2012, the annual number of ADA paratransit trips increased from 68 million to 106 million, while the average cost increased from \$14 to \$33 per trip (a cost increase of 138%, compared with an increase in the unit cost of fixed-route bus service of 82% over that same period).²⁷

Representatives from both transit agencies and private operators interviewed for this study expressed a strong interest in finding ways to harness emerging shared-use business models and technologies to increase mobility, lower costs, and improve the rider experience associated with paratransit and related services. Slowing the growth of costs could have a major impact on transit agencies' operational spending.

Several transit agency representatives noted the lack of clear federal guidance addressing some of the emerging partnership models—particularly about the degree to which public agencies' regulatory obligations extend to the private partners under marketing agreements and other models that are outside traditional relationships, where contractors clearly “stand in the shoes” of a public agency. Future research should explore areas where ambiguity remains in federal guidance and may hold back service delivery and innovation.

The technologies and business models of the new shared-use modes will likely find applicability to paratransit in two main ways:

First, individual technologies developed for new shared mobility services can be folded into existing paratransit operations as part of the ongoing technical evolution of the sector. Some applicable methods and technologies include:

- Interactive reservation, confirmation, schedule adjustment, and cancellation systems;
- Dynamic dispatch and routing of vehicles;
- Route combination for riders with similar origins/destinations;
- Mobile application-based payment integrated into reservation systems;

²⁷ FTA Report No. 0081: *Accessible Transit Services for All* (2014), p. 13

- Ability to track vehicle arrival and share trip details, location, and estimated arrival time with caregivers or other third-parties; and
- Real-time customer feedback.

The second, and perhaps more revolutionary, application would be the direct provision of transportation services to persons with disabilities by ridesourcing or microtransit operators. While this might seem like an extension of traditional taxi subsidies or dial-a-ride forms of demand response transportation, fundamental differences in the underlying business models make this more complicated—while offering the possibility for greater change if certain questions can be resolved.

Complexities of direct paratransit provision by ridesourcing companies

Much of the complexity regarding the role of current ridesourcing business models as they relate to public transportation springs from the nature of drivers' relationships with the ridesourcing companies (i.e., whether they are employees or independent contractors), which is currently being litigated in several jurisdictions. As long as drivers are considered independent contractors who can be provided with incentives, but cannot be subject to employment conditions, several hurdles make it difficult for ridesourcing companies to begin providing contracted paratransit services using federal monies. Those include:

- **FTA-required drug and alcohol testing**, which applies to any party contracted to provide transportation services for a public transit agency.²⁸ Testing is required for operators, dispatchers, and maintenance personnel for transit agencies or contractors receiving FTA funding, including taxi companies in a contractor (rather than vendor/voucher) relationship.²⁹
- **Liability and occupational safety relating to transfers and loading/unloading** of non-ambulatory riders. There is potential for injury for both drivers and passengers if drivers are not properly trained to help people with impaired mobility to load, unload and secure their wheelchairs.
- **Provision of door-to-door (vs. curb-to-curb) service**, which is determined by individual agency policy. However, even if the general practice is to provide only curb-to-curb service, a driver must "provide assistance to those passengers who need assistance beyond the curb in order to use the service unless such assistance would result in a fundamental alteration or direct threat."³⁰ Although providers may ask passengers to request assistance in advance, the driver must provide such assistance as would actually allow the passenger to use the transportation to get from the origin to destination, even if the policy is curb-to-curb service and if the passenger fails to request assistance help. Any private contractor being used to provide paratransit service would need to follow these rules.
- **Requirements for accepting accessible rides** and for accommodating wheelchairs or service animals. Ridesourcing companies have had inconsistent results in this area although it is of increasing interest to some companies.

²⁸ TCRP Report 121: Toolkit for Integrating Non-Dedicated Vehicles in Paratransit Service (2007), pp. 7-8

²⁹ Final rule at 49 CFR 655 (2013). Testing is required for organizations funded under Secs. 5307, 5309, and 5311, the major public transportation funding programs. Section 5310 organizations (which provide services specifically for the elderly and people with disabilities) are exempt from the testing requirements only if they do not provide any services for an agency funded under the other programs.

³⁰ FTA Circular C 7401.1 Sec. 8.3.1

- **Heightened vehicle safety and inspection requirements and insurance costs** associated with ADA provision and the transportation of fragile individuals. This goes beyond already identified questions about the applicability of non-commercial insurance in ridesourcing provision.

Even if the employment question is resolved, other considerations remain if ridesourcing or microtransit companies move into direct paratransit provision, such as:

- **Fleet-level accessibility requirements.** Unlike fixed-route transit fleets, which must be 100% accessible, demand-responsive transit service can be delivered with a fleet that is a mix of accessibility levels, as long as the level of access provided to riders with disabilities is equivalent to the level of service it provides to riders without disabilities.³¹ FTA guidance states that a mix of inaccessible vehicles may be used for provision of complementary paratransit “as long as accessible vehicles are dispatched to riders who need them.”³²
- **Fleet ownership prohibitions.** Questions of fleet-level accessibility may be moot in some jurisdictions—throughout the state of California, most notably—where TNCs are by definition prohibited from owning vehicles or fleets used in their operations.³³ In these situations, accessible vehicles would have to be provided by drivers under incentives from the companies (leased vehicles are permissible under the rules), or through partnerships with other providers who can own accessible fleets.
- **Buy America provisions.** Most federally funded rolling stock procurements above \$100,000 are subject to the requirement that vehicles and components be substantially manufactured and assembled in the United States. While there is some flexibility in the application of these requirements and waivers are available, the auditing requirements can add significantly to the unit cost of the kinds of smaller vehicles used for paratransit or other demand-responsive services.³⁴

The clearest way to address the first set of questions in the immediate term is for existing paratransit providers to consider licensing portions of these new ridesourcing technologies and deploying them using employees who are trained to work with riders who have with disabilities—pilots along these lines could start now. In the longer term, public agencies may work towards reforming or creating new classes of regulation for emerging models to encourage greater innovation from the private sector to help improve paratransit provision.

Public transit agencies can build on the innovations of shared-use modes for paratransit

A close reading of the regulations and a survey of the policies and practices of paratransit systems across the country suggests a number of applications for emerging shared-use models and associated technologies in serving ADA rides.

³¹ 49 CFR 37.77(b)

³² FTA Circular C 4710.1, Sec. 4.2.4

³³ CPUC Rulemaking 12-12-011

³⁴ National Cooperative Highway Research Program Research Results Digest 319: “Buy America Issues Associated with Procurement of Paratransit Vehicles Using FTA Funds” (2007)

These include:

- **Bringing reservation systems into the 21st century.** The paratransit sector is ripe for change in the area of reservations. For instance, the FTA found in 2014 that fewer than 15% of paratransit systems used voice-interactive or web-based applications for reservations, with electronic fare collection similarly slow to be taken up.³⁵ Telephone reservations will always need to remain available for reasons of accessibility, but considerable staff costs could be saved by the wider use of electronic customer interfaces. A number of transit agencies, including Capital Metro in Austin, have opened mobile application- or web-based reservation systems for customers who are able to use those options, while also preserving their live telephone reservation systems.
- **Using “concierge services.”** In several cities, shared mobility providers are piloting services that act as a human front-end to an electronic service interface for customers who want to access these services but either don’t have a smartphone or can’t use the default interface. Since it ultimately delivers the request to a ridesourcing provider, this is at present outside the realm of paratransit. But paratransit providers who move to dynamic reservation systems could use this option. Together with automated scheduling and rapid improvements in routing software (which are being quickly taken up by paratransit agencies), this could reduce reservation staff requirements.
- **Providing same-day paratransit rides.** Paratransit provision is governed by rules requiring advance reservation periods. These requirements generally end the calendar day before a ride, resulting in a customer experience marked by inflexibility and foreclosing the possibility of spontaneous choices. However, FTA guidelines rules do not prohibit same-day service. Instead, it would be considered “premium service” and not governed by the usual rules regarding complementary paratransit, including restrictions on service areas, fares, and permissibility of limiting riders based on purpose. A number of paratransit agencies are already providing such services to ADA-eligible passengers.
- **Making greater use of feeder paratransit.** Feeder paratransit service (rides to and from transit, rather than door-to-door service) is fairly rare now, likely because of expense and the additional trip time caused by transfers. More efficient linkages arising from the kinds of opportunities described above could make it a more useful format, and make more efficient use of existing transit infrastructure.

Private sector providers can improve and innovate ADA services

At present, new technology-enabled services for passengers with disabilities might not necessarily be provided within a strictly paratransit context, but they could still serve many of the same customers and do so with greater flexibility and better customer service. Private mobility providers can further enhance their ability to serve passengers with diverse needs by taking steps such as:

- **Expanding niche services.** Service models are beginning to emerge that recognize the different needs of passengers with disabilities, and the higher standards required of the drivers who work with them. Services like SilverRide (which is focused on older adults who can no longer drive, or prefer not to) hire and train drivers to accommodate the specific needs of their customers, including training in first aid, safe lifting and transfers, and improved communication.

³⁵ FTA Report No. 0081 (2014), p. 8

Companies like HopSkipDrive and Kango (which are essentially ridesourcing for children, with extra training, background checks, and outside certification of drivers) provide examples of how the shared mobility industry is creating new models to accommodate populations with specific needs and vulnerabilities. They are doing so in an area that could potentially be bolstered by federal guidance. However, the role of such services in relation to formal paratransit provision with federal funds involved is still evolving.

- **Providing incentives to drivers for taking accessible rides and using accessible vehicles.** Many of the most innovative features of new shared-use modes, and ridesourcing in particular, are based on the idea of using incentives to produce desired outcomes. To better serve riders with disabilities, companies could provide a way to request drivers willing to accommodate specific needs, and offer incentives for drivers to provide the needed services. Such a system could work best if there are clear state or local regulations that encourage companies to provide universally accessible service, particularly in situations where they receive public monies—which could prompt operators to absorb or underwrite the additional expense to drivers of leasing/purchasing and maintaining accessible vehicles.
- **Making accessible interfaces standard.** Riders might not necessarily want to use paratransit, but in many places it is the only option in for people who can't drive themselves. By making accessible interfaces available (i.e. interfaces that can easily be used with a screen-reader, and don't require dropping a pin or dragging a map), shared mobility providers could make their services useful for a wider range of customers.

5: Emerging Mobility Business Models and Partnerships

A number of business models are emerging that include new forms of public-private partnership for provision of mobility and related information services. Public entities, including transit agencies and local transportation departments, are already engaging with private operators and using new technologies from the shared mobility world.

This section describes several efforts that can provide examples for how interested agencies can begin to collaborate or incorporate new approaches into their operations.

Cross-modal trip-planning, reservation, and payment application integration. Several public entities have taken the lead in establishing partnerships to integrate existing transportation services with private mobility providers. These efforts can include integration of fare media, trip-planning technology, and physical integration of modes. Such public-private partnerships are important because they can help increase ease-of-use and transfers between disparate modes.

- **Buffalo Niagara Medical Campus GO BNMC Program, Buffalo, NY.** Especially notable because the effort is led by a regional institution and large employer rather than a transportation agency, the GO BNMC initiative connects campus employees to alternative transportation options, linking access to carsharing, bikesharing, shuttles, secure bicycle and car parking, and other transportation services through campus IDs that act as contactless smart cards. BNMC also received funding from the New York State Energy Research and Development Authority to launch a second pilot focused on the creation of an Integrated Mobility Hub where employees and residents can access and connect between an array of transportation services at a single location.³⁶
- **Go LA multimodal trip planning mobile application.** The City of Los Angeles partnered with Xerox to launch the Go LA wayfinding application in January 2016. The application aggregates every available mode of transportation—including transit, carsharing, ridesourcing, private bike, and eventually bikesharing—for a given route and calculates the time, cost, and carbon footprint for each option. As the system learns about its users' individual travel preferences, it will eventually recommend and highlight personalized commuting options. Future updates to Go LA will also include a single payment system that lets users pay for multiple transportation options through the application.³⁷
- **TriMet-GlobeSherpa Partnership, Portland.** Portland's TriMet transit system announced in March 2016 that riders will soon be able to hail a Lyft ride or reserve a car2go vehicle using its new mobile ticketing application, developed by payment solutions provider GlobeSherpa (now

³⁶ <http://www.bnmc.org/bnmc-access-principles/#sthash.e4JIYNBf.dpuf> ; <http://www.bnmc.org/bnmc-inc-awarded-1-million-nyserda-develop-green-commons-2/#sthash.OEOEghGj.dpuf>

³⁷ <http://fortune.com/2016/01/28/xerox-los-angeles-traffic/>

moovel North America). The multimodal integration will be powered by RideTap, a software tool that lets apps integrate with shared use systems and other transportation options.³⁸

- **Twin Cities Hourcar/Metro Transit multimodal integration.** In 2015, the Twin Cities carsharing company Hourcar upgraded its vehicle technology to recognize the chips in Metro Transit Go-to cards. This technology allows Hourcar members to swipe a registered transit pass to lock and unlock the doors of any Hourcar vehicle.³⁹
- **Ventra Mobile Application, Chicago.** Transit users across the Chicago area can access and pay for rides with the region's three transit agencies—the Chicago Transit Authority (CTA), Metra and Pace—from their smartphones using the Ventra mobile application, which was developed by Cubic Transportation Systems and RideScout/GlobeSherpa.⁴⁰ Riders on Metra can use their phones to display their train pass.

Microtransit/dynamic demand response. These models extend the reach of fixed-route transit into lower density areas with dispersed ridership, provide service in core areas outside of peak travel times, or augment fixed route transit in corridors that are operating at or beyond capacity. Using dynamically dispatched multi-passenger vehicles such as vans, shuttles, or buses, the services optimize routes and stops by balancing multiple customer requests on the fly. Rather than providing door-to-door service, these models may use a service zone with origin and destination points determined to serve the mix of customer requests at a given moment. The services listed below generally connect to fixed-route public transit services at one end of the trip. Some are public-private partnerships, while others are operated directly by the transit agencies themselves using emerging reservation and routing technologies.

- **Denver Regional Transportation District (RTD) Call-n-Ride Program.** Denver RTD's Call-n-Ride provides dynamic shuttle service within 20 service zones in lower density areas of the metro area, with a focus on connecting riders with bus routes, rail stations, and Park-n-Ride sites. The system builds routes from phone- or web-based reservations that can be made two hours to two weeks in advance, and is the same cost as a local fare elsewhere in the RTD system. Some Call-n-Ride service areas also offer flex route service during morning and evening rush-hours, which provides reservation-free rides from designated stops within the service area.⁴¹
- **Kansas City Area Transportation Authority (KCATA)/Bridj pilot.** In March 2016, Kansas City's transit agency launched a one-year pilot program that uses the transit agency's drivers and KCATA-branded vehicles to operate a microtransit system built on the Bridj technology platform. The pilot is based in two zones, around downtown Kansas City, MO, and the University of Kansas Medical Center district (KU Med Center), just across the state line in Kansas City, KS—a large suburban campus that is poorly served by public transit and experiences high peak-hour congestion. During weekday rush hours, riders can use the Bridj mobile application to request rides within and between the two zones, for \$1.50 fare (the same as a KCATA bus ride but paid

³⁸ <http://www.masstransitmag.com/news/12188792/trimet-tickets-app-will-soon-let-riders-hail-lyft-reserve-car2go>

³⁹ <http://www.hourcar.org/news/2015/09/go-cards-can-now-be-used-for-both-transit-and-hourcar>

⁴⁰

https://metrarail.com/metra/en/home/utility_landing/newsroom/newsroom_archive/2014NewsroomArchive/cta--metra-and-pace-announce-mobile-ventra-app.html

⁴¹ <http://www.rtd-denver.com/callNRide.shtml>

through the Bridj app), and the platform matches groups of riders and dynamically generates routes based on common origins and destinations.⁴²

- **Milton, Ontario GoConnect Pilot.** Piloted between May 2015 and April 2016 in suburban Toronto, this demand-response pilot addressed passenger connectivity challenges between the regional commuter rail system (GO Trains) and a smaller suburban system through an application-based system. The service operated during the weekday morning and evening peak periods, connecting customers to and from their preferred GO Trains. Shuttles operate on optimized routes, based on reservation requests through the RideCo software platform, which dynamically adjusts routes and pick-up/drop-off locations to maximize operational efficiency and minimize real-time travel delays.⁴³
- **Santa Clara Valley Transportation Authority (VTA) FLEX pilot.** In January 2016, the VTA launched an on-demand, dynamic transit program that provides connection service between regular transit stops and high-density employment centers and retail centers within a 3.25-square-mile section of Santa Clara County. After customers request and pay for rides via a smartphone application, the system creates optimal shuttle routes among a network of stops.⁴⁴
- **West Salem Connector.** Salem-Keizer (Oregon) Transit's Cherriot bus system began piloting a zone-based dynamic shuttle system in June 2015. The service provides dynamically routed trips among a network of 26 set stops in the suburban area of West Salem, OR, with the aim of connecting dispersed riders to the transit agency's scheduled routes.⁴⁵ The system, based on the DemandTrans reservation/scheduling platform, takes web and phone reservations between 30 minutes and two weeks before a given ride to generate routes and stops, and uses the same fare system as the transit agency's regular service. Using the transit agency's vehicles and drivers, the system is being tested as a replacement for several low-ridership routes, with the transit agency instead focusing on providing greater frequency along key corridors, with the new service acting as a feeder based on actual demand.⁴⁶

Private access to public rights-of-way. Use of the public right-of-way by private operators—for parking, passenger loading/unloading, deliveries, or travel in limited-access zones such as dedicated transit lanes—can lead to conflict, especially in busy areas with many competing demands for curbside access or parking. However, it can also lead to opportunity. Some cities have taken a proactive approach to managing private use of street parking spots, transit stops, and other common areas, and used these new pilots and ordinances to generate revenue, encourage compliance, and ensure that mobility companies help to serve the public interest. Several jurisdictions have tied these policies to broader objectives, such as ensuring equity in the geographic distribution of services and addressing climate goals.

⁴² Kansas City Area Transportation Authority. "Ride KC: Bridj Service Begins March 7." (Press release.) 2 March 2016. http://www.kcata.org/news/ride_kc_bridj_begins_service_march_7, <http://www.theverge.com/2016/2/11/10962182/ford-bridj-kansas-city-on-demand-bus>

⁴³ <http://www.milton.ca/en/News/index.aspx?newsId=932006f3-6c47-48aa-b0b5-a4d79d3c5be4>

⁴⁴ <http://www.vta.org/getting-around/vta-flex>

⁴⁵ Salem-Keizer Transit. "West Salem Connector: Call or Click, Book Your Trip." 2015. <http://www.cherriots.org/en/connector>.

⁴⁶ Southward, Brandon. "Cherriots to expand West Salem service." *Statesman Journal* (Salem, OR), 2 June 2016.

- **DC Carshare Street Space Ordinance.** Beginning in 2011, the District of Columbia Department of Transportation (DDOT) established a program to allow one-way carsharing members to park shared vehicles in residential permit parking zones throughout the city. The ordinance requires carsharing providers to maintain an area of operation that includes the entire District of Columbia and to keep at least one percent of its fleet available in each ward of the city at all times. Additionally, DDOT's ordinance requires that a set number of carsharing vehicles be located in low-income neighborhoods as identified by DDOT, even if such locations are not desired or requested by the company.⁴⁷
- **San Francisco Municipal Transportation Agency Commuter Shuttle Pilot.** The SFMTA launched an 18-month Commuter Shuttle Pilot Program in August 2014, with the goal of minimizing the negative impacts of the region's many private commuter shuttles while offering a framework to manage their operation. Central to the pilot was the creation of a limited network of shared Muni and commuter shuttle stops throughout the city. To use the network, shuttle service providers had to apply for a permit and pay a fee of \$3.67 per stop-event (as of Fiscal Year 2016). Meanwhile, the program was enforced by the SFMTA to ensure that shuttle operators followed all rules and regulations outlined in the pilot.⁴⁸
- **Seattle Carsharing Ordinance.** Flowing in part from local climate action goals, this 2015 ordinance realigns curb-access priorities while significantly raising the cap on "free-floating" (one-way) carsharing in the city, allowing carsharing companies to eventually operate a total of 3,000 one-way vehicles and tying this total to full coverage of the city. At the same time, the law seeks to replace revenue lost to carsharing's use of metered parking spaces by both one-way and round-trip vehicles. The ordinance sets annual permit fees for free-floating vehicles (\$1,730 per vehicle, which includes access to both metered and residential permit spaces, with annual adjustment for actual use of metered spaces) and for dedicated on-street spaces for round-trip carsharing (\$3,000 per metered space and \$300 per non-metered space). The program initially caps each one-way operator at 500 vehicles, with a requirement that each establish within two years a service area covering the entire city, at which time they may operate up to 750 vehicles.⁴⁹

Service Links and Handoffs. Several transit agencies have begun working directly with ridesourcing companies and other private providers to link their services or to promote handoffs through targeted marketing agreements. These arrangements—which include first/last mile partnerships, linked mobile apps, and guaranteed ride home programs—can help facilitate the creation of a robust, interconnected network of mobility options that supports car-free and car-light living.

- **Dallas Area Rapid Transit/TNC Partnerships.** In April 2015, DART announced a partnership with Uber that would allow transit riders to connect with Uber through DART's GoPassSM mobile ticketing application. DART customers are able to "walk through" the agency's application to access Uber's app. To encourage people to try the new combination, Uber offered a free first ride (up to \$20) to new customers. In October 2015, DART announced a similar partnership with Lyft.⁵⁰

⁴⁷ <http://ddot.dc.gov/page/street-carsharing-program>

⁴⁸ <https://www.sfmta.com/projects-planning/projects/commuter-shuttle-program-2016-2017>

⁴⁹ Seattle Municipal Ord. 124689, http://clerk.seattle.gov/~legislativeItems/Ordinances/Ord_124689.pdf

⁵⁰ <http://www.dart.org/news/news.asp?ID=1179>; <http://www.dart.org/news/news.asp?ID=1213>

- ***King County Metro and Redmond Real-Time Rideshare and Emergency Ride Home Programs (Seattle and Redmond, WA).*** King County Metro and the City of Redmond have partnered with iCarpool, a mobile ridesharing app, to facilitate carpooling among local commuters. Drivers and riders are able to share the cost of the trip via an automated in-app payment system. Drivers post their trip on the application up to an hour before leaving, and riders searching for a trip along the same route or to the same destination will be matched with the driver. Through the service's Emergency Ride Home program, carpool users who can't get a ride home through the iCarpool application are also eligible to receive up to eight free rides with Uber or Lyft per year. The system is designed to allow users to take part in the program with the confidence that they'll be able to get home if an unusual situation were to arise, such as a child care emergency or an unplanned late night at work.⁵¹
- ***Metropolitan Atlanta Rapid Transit Authority/Uber Partnership.*** In July 2015, MARTA launched a "Last Mile Campaign" in partnership with Uber. Through the partnership, users who are new to Uber can sign up with a promotional code for a first free trip, up to a \$20 value.⁵²
- ***Pinellas Suncoast Transit Authority-Taxi/TNC Partnership.*** Through its Direct Connect program, announced in February 2016, the PSTA will pay half the cost of an Uber or local taxi ride (up to \$3) to or from transit to help provide first/last mile connections in the region. Designed to facilitate use of local bus service, the program allows riders to use Uber (in Pinellas Park, FL) or United Taxi (in Pinellas Park and East Lake, FL) to travel within a specific geographic zone to or from a series of designated stops. From there, riders can connect with the regular PSTA public transit bus system. On the return trip, they can use Uber or United Taxi to travel from the designated stop back home or to work.⁵³

⁵¹ https://www.redmond.gov/Transportation/Programs/redmond_real_time_rideshare_with_icarpool

⁵² <https://newsroom.uber.com/us-georgia/uber-marta-connecting-the-last-mile/>;
<http://georgiastatesignal.com/marta-partners-with-uber-to-take-riders-the-extra-mile/>

⁵³ <http://www.psta.net/press/02-2016/direct-connect/index.php>

Conclusions

This research points to actions that public transit agencies and other public-sector entities can take to build on the mobility innovations of technology-enabled shared use modes. It identifies opportunities for cooperation and also suggests regulatory enhancements, institutional realignments, and forms of public-private engagement that would allow innovation to flourish, while still providing mobility as safely, broadly, and equitably as possible.

Change performance metrics to make efficient mobility the goal

- *Take a big picture approach to metrics* that drive performance and planning. Current metrics that are focused solely on operational measures such as route ridership, unlinked trips, passenger revenue miles, or road capacity and congestion are not sufficient for gauging performance in the expanding mobility ecosystem. Improved metrics should take into account the entire mobility picture, including increases in linked, multimodal trips and reductions in solo car trips, vehicle miles traveled, and transportation-related climate impacts.

Extend fare integration and mobile payment to goals beyond smoothing farebox interactions, such as subsidy administration, mode-shift goals, and gathering ridership data

- *Integrate fare payment systems* to simplify the subsidy of linked rides, such as the Pinellas Suncoast Transit Agency's pilot to partially subsidize transit-linked ridesourcing trips, or King County Metro Transit's emergency ride home program. In-app payment could draw from a pool of voucher money established through agreement between the company and the transit agency that is reconciled on the back end.
- *Make use of new technologies' rich data gathering capabilities.* As part of fare integration, transit agencies can partner with aggregators and other mobility providers to more accurately measure both transit usage and cross-mode linked trips, since both are measures of trips that aren't taking place in personal autos. Increases in linked trips, both within and across modes, should be a performance goal.
- *Use Title VI equity analyses* relating to fare medium changes to understand how to broadly distribute the benefits of integrated payment and information.

Keep information open and widely available for the broadest benefit

- *Build in accessibility from the ground up* whenever information or payment solutions are pursued—this should be part of every payment or information system RFP.
- *Continue to develop common standards for payment, storage of customer information, and privacy.* Ideally, public authorities should actually own and maintain cross-modal data in an integrated system.
- *Ensure data reciprocity from the private sector,* which benefits greatly from open public data. A “walled garden” model will not work for ridesourcing companies and other private operators if they expect to take part in a wider mobility ecosystem. Public transit operators, planners, researchers need this data to understand how people are moving and where intervention may be needed.

Shared Mobility and the Transformation of Public Transit

- *Support the development and adoption of shared-mobility information standards.* This is already happening with the general bikeshare feed specification, but something similar is needed for carshare, ridesourcing, microtransit, and other new modes.
- *Use open data and APIs,* continue improvement of feeds, and encourage private sector innovation. Making contracting more flexible for transit agencies will help ensure they are not locked into a single vendor's proprietary software and hardware.

Lay the groundwork for strong public-private partnerships and targeted investments in the mobility system, including public transit and shared modes

- *Explore opportunities and challenges* for public transportation as they relate to technology-enabled mobility services, including suggesting ways that transit can learn from, build upon, and interface with these new modes.
- *Hold information-sharing sessions* to introduce regional stakeholders to one another and to private industry representatives. Especially when previously unknown business models are entering a region for the first time, much of the groundwork has to do with establishing relationships and trust among players and making sure everyone's goals are on the table.
- *Link objectives to local conditions,* and seek to understand the true state of the shared mobility landscape before making permanent policy adjustments or entering into long-term agreements.
- *Map local mobility assets, deficits, and other local needs* to make sure services, policies, and investments are directed to where they'll have the greatest impact.
- *Support the establishment of an information clearinghouse* that can effectively capture, digest, and disseminate practices regarding public-private partnerships for provision of mobility and related information services, and continue to identify areas of need for future research.
- *Use requests for information (RFIs)* to get an accurate sense of private operators' capacities and needs before issuing requests for qualifications or proposals. This will help ensure that, early in the process of pursuing public-private ventures, both sides know what the other needs, can supply, and is prepared to do.

Maintain accessibility and equity as central mandates for urban and regional mobility, especially with an evolving mix of public and private participants

- *Address inequities in access to information,* since information is the currency of the new mobility system. The capacity to readily use tools for information, schedules, booking, and payment must be ensured for those who face barriers related to cost, technology, technical knowledge, or disability.
- *Consider unbanked individuals.* People without bank accounts need accommodations related to cost and payment options, especially as fare media and payments increasingly migrate to mobile platforms. In Chicago, Philadelphia, and several other cities, mobility and transit pass programs targeting lower income residents have successfully used retail outlets to maintain the ability to use cash, and found that lower payment increments and more short term options can improve access and more widely spread the benefits of transportation investments.
- *Evaluate the use of new modes* such as microtransit and one-way carsharing to increase transit access in outlying communities, and conduct targeted outreach to educate residents about first/last mile solutions. The suburbanization of poverty has resulted in longer commutes, poorer job access, and greater reliance on car ownership for many who can least afford it.

Transform public transportation agencies into mobility agencies

- *Address mobility beyond direct provision of transportation services*—especially through spreading awareness and training people how to use the full mobility menu to reduce the need for personal vehicles. This is another locus and role for mobility management.
- *Align goals across agencies.* Coordinate transit and transportation operations—along with planning and regulation of bikesharing, carsharing, ridesourcing, shuttles, parking, and curb access—and attempt to align work across all of these regulatory areas with overarching mobility goals. The San Francisco Municipal Transportation Agency and several agencies in Seattle are transforming themselves into mobility managers, with responsibilities that go beyond a public utility model of transit provision or a streets department.
- *Create a network of mobility managers* at different levels (e.g., regions, municipalities, transit agencies, and large employers) to communicate and coordinate mobility needs across departmental, jurisdictional and public/private lines.
- *Create cross-agency working groups* to regularly get multiple entities—including transit agencies, departments of transportation and streets departments, business affairs divisions, consumer watchdogs, land-use divisions, planners, and public safety agencies—all in the same room to work towards policies that ensure they're not working at cross-purposes in pursuit of similar goals, despite the conflicting priorities and stakeholder groups that may remain.

Appendices

Appendix A: Public Agency and Private Operator Interviewees.....	A-1
Appendix B: Survey Methodology and Additional Data	A-4
Appendix C: Survey Instrument	A-9
Appendix D: Ridesourcing and Transit Travel Time Comparison.....	A-20
Appendix E: Ridesourcing Demand and Transit Capacity Calculation	A-30
Appendix F: Maps of Ridesourcing and Transit Demand and Capacity	A-33

Appendix A: Public Agency and Private Operator Interviewees

Table 1: Public agency interviews

Market	Agency	Individuals, roles
Austin	Capital Metro	Javier A. Argüello, Director, Long Range Planning Jennifer Govea, Service Analysis Manager Roberto Gonzalez, Director of Service Planning Lawrence Deeter, Transportation Planner
Austin	Austin Transportation Department	Gordon Derr, Assistant Director of System Development and Regulation Laura Dierenfield, Active Transportation Division Manager
Austin	Capital Area Metropolitan Transportation Organization	Lisa Weston, Senior Planner Alex Kone, Senior Planner Julie Mazur, Commute Solutions Coordinator Geena Maskey, Planner
Boston	City of Cambridge	Joe Barr, Director of Traffic, Parking, and Transportation Adam Shulman, Transportation Planner, Traffic, Parking, and Transportation Stephanie Groll, Parking and Transportation Demand Management Planning Officer
Boston	Massachusetts Department of Transportation	Kristin Slaton, Project Director, massRIDES Scott Hamwey, Manager of Long Range Planning Price Armstrong, Transit and Capital Analyst Jennifer Slessinger, Transportation Planner Curtis Bradley, Transportation Program Planner Heather Hume, Manager of Paratransit Programs Dustin Rhue, Office of Transportation Planning
Boston	City of Boston	Gina Fiandaca, Commissioner, Boston Transportation Department Stephen Maguire, Director, Parking Clerk Chris Osgood, Co-Chair, Mayor's Office of New Urban Mechanics Greg Rooney, Director of Enforcement, Boston Transportation Department
Boston	Massachusetts Bay Transportation Authority	Greg Strangeways, Manager of Service Planning Charles Planck, Assistant General Manager, Operations Strategy and Support
Chicago	Chicago Metropolitan Agency for Planning	Elizabeth Schuh, Principal Planner, Policy and Programming Jesse Elam, Principal Planner, Policy and Programming
Chicago	Chicago Transit Authority	Michael Connelly, Vice President, Scheduling and Service Planning Jonathan Czerwinski, Sr. Manager, Service Planning
Chicago	Regional Transportation Authority	Leanne Redden, Executive Director

Shared Mobility and the Transformation of Public Transit
Appendix A: Public agency and private operator Interviewees

Market	Agency	Individuals, roles
Chicago	Metra	David Kralik, Department Head, Long Range Planning James Bonistalli, Director of Marketing Virginia Chandler, Market Development
Chicago	Chicago Department of Transportation	Kevin O'Malley, Deputy Commissioner, CDOT Sean Weidel, Assistant Commissioner, CDOT
Chicago	Pace Suburban Bus	Michael Bolton, Deputy Executive Director, Strategic Services Lorraine Snorden, Planning Services Department Manager
Los Angeles	City of Santa Monica	Francie Stefan, Manager, Strategic & Transportation Planning
Los Angeles	Southern California Association of Governments	Marco Anderson, Senior Regional Planner
Los Angeles	City of Pasadena	Paul Backstrom, Transportation Deputy to City Councilmember Mike Bonin
Los Angeles	Los Angeles Metropolitan Transportation Authority	Jacob Lieb, Sustainability Policy Manager Diego Cardoso, Executive Officer , Transit Corridors, Active Transportation & Sustainability Laura Cornejo, Deputy Executive Officer of Countywide Planning and Development
San Francisco	San Francisco Municipal Transportation Agency	Michael Schwartz, Senior Transportation Planner Sarah Fine, Transportation Planner Tilly Chang, Executive Director David Uniman, Deputy Director for Planning
San Francisco	Bay Area Rapid Transit	Bob Franklin, Customer Access & Accessibility Department Manager Mariana Parreiras, Access Coordinator
Seattle	King County Metro	Carol Cooper, Supervisor, Transit Market Development Stephen Hunt, Transportation Planner Ref Lindmark, Transportation Planner Daniel Rowe, Transportation Planner
Seattle	City of Seattle—Department of Transportation	Kiersten Grove, Senior Transportation Planner Nicole Freedman, Director of Active Transportation Holly Houser, Executive Director, Puget Sound Bike Share Cristina VanValkenburgh, Mobility Programs Manager
Seattle	City of Seattle—Dept. of Finance & Administrative Services	William Edwards, Director of Regulatory Compliance & Consumer Protection Kara Main-Hester, Strategic Advisor, Regulatory Compliance & Consumer Protection
Seattle	King County—Records & Licensing Services Division	Megan Pederson, Deputy Director Sean Bouffiou, Finance Administrator
Seattle	Puget Sound Regional Council	Alex Krieg, Senior Planner

Shared Mobility and the Transformation of Public Transit
Appendix A: Public agency and private operator Interviewees

Market	Agency	Individuals, roles
Washington, DC	Washington Metropolitan Area Transit Authority	Shyam Kannan, Managing Director of Planning Jennifer Weeks, Director of Strategic Planning Kristin Haldeman, Manager, Access Planning & Policy Analysis
Washington, DC	District Department of Transportation	Sam Zimbabwe, Associate Director, Policy, Planning and Sustainability
US	Federal Transit Administration	Jeff Spencer, ITS Program Manager Gwo-Wei Torng, Director, Office of Mobility Innovation Jamie Pfister, Director, Office of Transit Programs Vincent Valdes, Associate Administrator, Office of Research, Demonstration and Innovation

Table 2: Shared-use mobility operator interviews

Operator	Individuals, roles
Lyft	Emily Castor, Director of Transportation Policy
Bridj	David Block-Schacter, Chief Data Scientist
Zipcar	Justin Holmes, Director, Corporate Communications & Public Policy
Ridescout	Joseph Kasper, Co-Founder/CEO Brian Stanley, Enterprise Solutions Patti Kelly Niewolny, Communications Director
Bikeshare of Austin	Elliott McFadden, Executive Director

Appendix B: Survey Methodology and Additional Data

The user survey was distributed through both private shared-mobility operators and transit agencies in September and October 2015.

The survey sample frame included adult residents of the study regions who have used one or more shared-use modes, including transit. The researchers requested distribution by transit agencies and shared mobility operators in all of the seven study markets, and also in New York City. The recruitment method was through invitations emailed and distributed via social media by cooperating agencies and operators, inviting customers to complete a web-based survey instrument. A link was directly emailed by distribution partners to more than 75,000 email recipients in addition to a large number of newsletter and social media followers, and received 4,551 at least partial responses. Provider-specific links, called collectors, allowed tracking of response sources and permitted deactivation of particular channels at the end of a two-week open period. The overall count represents a net response rate of 6.0% for the sources the researchers were able to track. Distribution partners in each market are listed in the table below.

Table B-1: Survey distribution partners, dates, and response counts

Market	Agency or operator	Field dates	Total responses
Austin	Car2go	9/17/15-10/1/15	539
Boston	Motivate/Hubway	10/8/15-10/22/15	69
Chicago	Motivate/Divvy	9/24/15-10/8/15	424
Los Angeles	LA Metro	10/6/15-10/20/15	653
New York City	Motivate/CitiBike	9/23/15-10/7/16	508
San Francisco Bay Area	BART	9/18/15-10/8/15 (staggered samples)	179
San Francisco Bay Area	Motivate/Bay Area Bikeshare	9/16/15-9/30/15	5
Seattle	Car2go	9/17/15-10/1/15	992
Seattle	Motivate/Pronto Cycle Share	9/15/15-9/29/15	30
Washington, DC	WMATA	9/16/15-9/30/15	830
Washington, DC	Motivate/Capital Bikeshare	9/17/15-10/1/15	74
Washington, DC	Car2Go	9/17/15-10/1/15	248
Total			4551

The survey contained an initial screening question about overall experience with new shared-use modes, asked whether respondents had “ever used a shared form of transportation like bike-sharing, car-sharing, or ride-sharing like Uber or Lyft.” Respondents who answered “No” went immediately to a portion of the survey that only asked about transit technology, followed by collection of demographic information, including home zip code (mapped in Figure B-1 for all respondents). The geographic distribution of home zips generally matches the distribution locations.

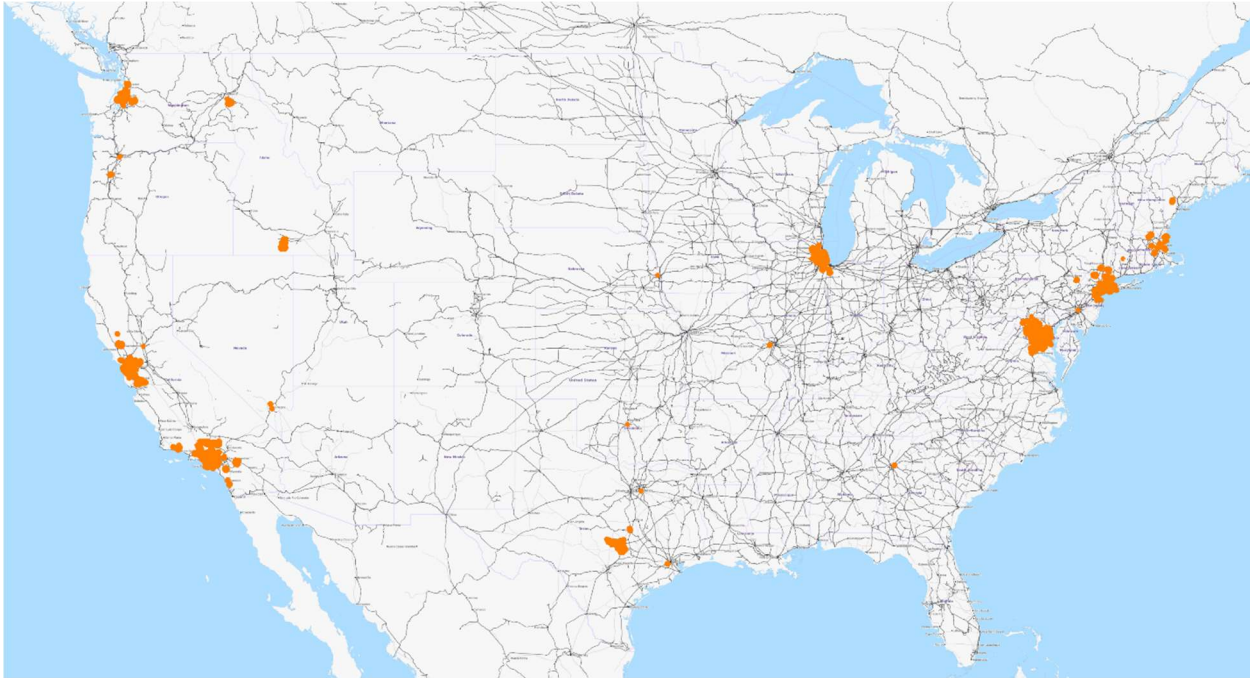


Figure B-1: Reported home zip codes of survey respondents.

Sampling considerations

Because the researchers were limited to working with convenience samples in each market—those individuals able to be reached via the partners who agreed to distribute the survey, all of whom were people who had previously supplied their email addresses to the agencies or operators—we must be cautious about inferring to the wider population of shared mobility and transit users and certainly to the general population. The survey was administered via an online form, and links to this form were distributed by email. This implies a basic level of technological facility, and also a willingness to participate in research about transportation. Also, the survey took place in several of the largest, densest, and most expensive cities in the country, which were chosen for this study specifically because of their known high levels of shared mobility usage. Thus the sample is likely over-representative of higher-income, more highly educated individuals compared to the general US public.

We should also make note of the small sample sizes in some markets relative to others: we received only 69 responses via the Boston channel, and fewer than 200 in San Francisco. In addition, we might expect some bias related to the mode of the distribution channels for the various surveys. In Los Angeles and San Francisco, the survey was distributed almost exclusively via the transit agencies; in Boston, Chicago, and New York, the survey was distributed solely via bikeshare operators; and in Austin and Seattle the primary channel was a carsharing operator. One subpopulation this distribution method might miss would be people who use ridesourcing exclusively among shared modes, including transit. Unfortunately the researchers don't have a way of estimating the size of this population because so little systematic knowledge currently exists about levels of ridesourcing usage in urban areas and among the traveling population overall. Ongoing research—from other behavioral surveys, public and private operator data, personal travel inventories, and other data sources—is needed to continue building the understanding of the use and effects of ridesourcing and other shared modes. Overall, the familiarity with and level of information about shared-use modes in the general population is likely to differ somewhat from what we found from our respondents. However, since the subject of this report is the

interaction of shared-use modes and new mobility technologies with transit, the researchers believe it made sense to focus this initial descriptive effort as we did.

Response rate

The survey was distributed through both private shared-use operators and transit agencies starting in mid-September 2015. The survey link was directly emailed to more than 75,000 email recipients plus a large number of newsletter and social media followers, and received 4551 at least partial responses, of which 3548 reached the end of the survey. The number of responses to individual questions varied, with some respondents skipping individual questions while answering others later in the survey.

The overall count represents a net response rate of 6.0% for the sources we were able to track. Response rates from the collectors of individual agencies and operators ranged from less than 2% to more than 15%. Response rate was calculated as the proportion of responses to successful (non-bounce) email deliveries. Since we don't have access to the web social media metrics of the distributing organizations, we did not attempt to calculate response rate for those mediums.

The circulated version of the survey instrument is attached in Appendix C.

Additional data

This section contains additional tables of data that informed the main findings.

Frequency of use of all modes, by top shared-use mode					
Frequency by mode	Top Mode				
	Bikesharing	Carsharing	Ridesourcing	Public bus	Public train
Public bus					
Daily/almost daily	3%	3%	3%	63%	14%
1-3 times a week	18%	14%	10%	23%	21%
1-3 times a month	39%	25%	23%	11%	28%
A few times a year	31%	34%	35%	3%	23%
<1/yr	9%	24%	30%	0%	14%
Public train					
Daily/almost daily	11%	2%	4%	11%	77%
1-3 times a week	33%	3%	6%	13%	18%
1-3 times a month	39%	13%	18%	21%	7%
A few times a year	16%	41%	33%	34%	1%
<1/yr	2%	38%	38%	16%	0%
Bikesharing					
Daily/almost daily	70%	1%	2%	2%	12%
1-3 times a week	24%	2%	6%	6%	20%
1-3 times a month	8%	5%	8%	6%	15%
A few times a year	1%	10%	13%	9%	8%
<1/yr	0%	78%	69%	68%	43%
Carsharing					
Daily/almost daily	1%	8%	0%	1%	0%
1-3 times a week	5%	31%	12%	16%	6%
1-3 times a month	14%	40%	33%	39%	15%

Frequency of use of all modes, by top shared-use mode					
Frequency by mode	Top Mode				
	Bikesharing	Carsharing	Ridesourcing	Public bus	Public train
A few times a year	23%	20%	29%	20%	21%
<1/yr	53%	2%	23%	18%	55%
Ridesourcing					
Daily/almost daily	1%	1%	7%	0%	1%
1-3 times a week	10%	14%	40%	12%	13%
1-3 times a month	27%	29%	42%	31%	29%
A few times a year	21%	22%	8%	20%	23%
<1/yr	37%	30%	2%	30%	32%
Driving alone					
Daily/almost daily	9%	41%	49%	11%	13%
1-3 times a week	16%	24%	23%	23%	24%
1-3 times a month	21%	11%	9%	17%	17%
A few times a year	19%	7%	6%	12%	20%
<1/yr	33%	16%	13%	30%	26%
Driving with family/friend					
Daily/almost daily	5%	19%	25%	7%	6%
1-3 times a week	20%	41%	40%	37%	28%
1-3 times a month	32%	19%	23%	28%	28%
A few times a year	30%	11%	9%	15%	25%
<1/yr	11%	9%	3%	9%	12%

Figure B-2: Frequency of use of all modes, by top mode.⁵⁴ Cell shading reflects the relative magnitude of percentages, from lowest (red) to highest (green).

In addition to asking for home zip code, the survey asked respondents in which metro area they generally used their top shared-use mode—this distinction was intended to elicit information about where the shared-mode use actually took place, even if these services were not available near respondents' homes (for example, people who use the public train and bikesharing when they're in Washington, DC, even though their hometown only has bus service).

As would be expected, all but a few respondents told us that they most commonly use shared-use modes in one of the eight metro areas where the survey was fielded (the seven study cities plus New York City). We received fewer than 100 responses to this question for either Boston or San Francisco, reinforcing the caution we must take with what we infer from our results about those areas due to their small sample size.

⁵⁴ Q7: "How often do you travel in each of these ways?" Crosstabbed on Q4: "Which shared-use service do you use most often?"

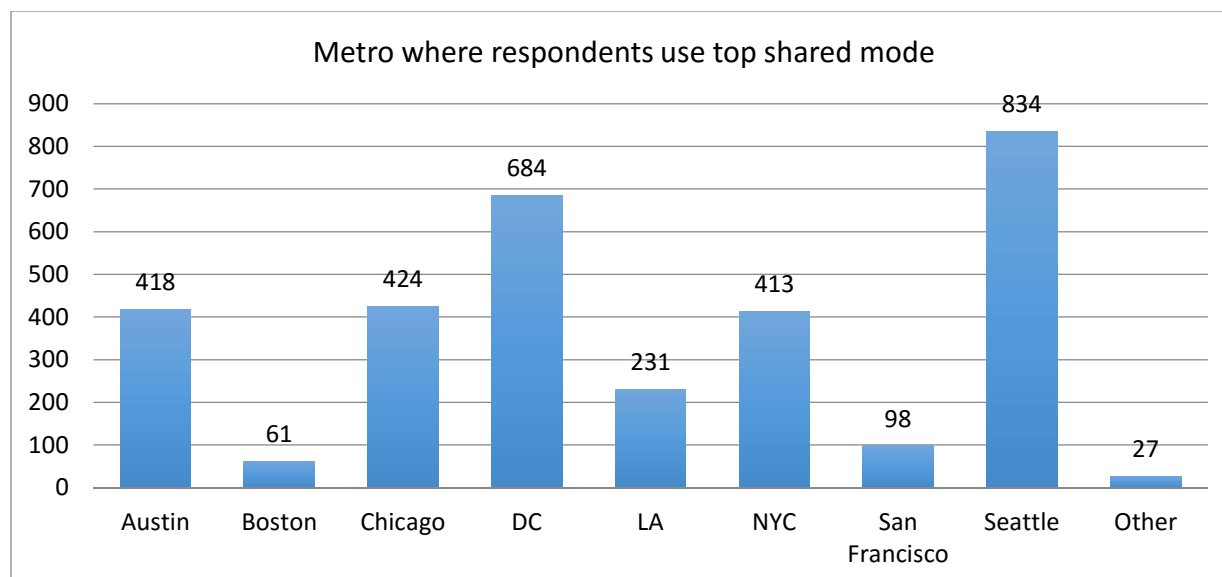


Figure B-3: Metro area where respondents use top shared mode.

Trains are prevalent as the top mode in every city with established heavy rail (Boston, Chicago, DC, NYC, and San Francisco), and Los Angeles has a significant train share even at a relatively early point in its rail system's build-out. Austin is notable as the only metro where the top mode is not a bus or train. It has the largest shares by far of respondents who choose carsharing or ridesourcing as top modes, reflecting a transportation infrastructure based on solo driving that is only starting to be retrofitted with more fixed-guideway transit and emerging shared modes.

In what metro area do you most often make trips by your top shared mode? (mode as percentage of respondents choosing each metro)								
Mode	Metro							
	Austin	Boston	Chicago	DC	LA	NYC	SF	Seattle
Bikesharing	2%	38%	31%	5%	0%	39%	0%	2%
Carsharing	36%	2%	0%	4%	3%	1%	0%	23%
Ridesourcing	30%	3%	7%	5%	11%	1%	9%	10%
Public bus	30%	7%	13%	14%	59%	3%	17%	61%
Public train	2%	51%	49%	72%	28%	57%	73%	5%

Figure B-4: Top shared mode by respondent metro area. Cell shading reflects the relative magnitude of percentages, from lowest (orange) to highest (blue).

Appendix C: Survey instrument

Learning more about the relationship between public transit and other forms of transportation

About this Survey

This survey is about important transportation issues, including how, when, and why people use different ways of getting around. It should take 10-15 minutes to complete.

Your participation is voluntary, and all responses are optional. We collect no personally identifiable information as part of this survey. We know your time is valuable, and very much appreciate your taking the trouble to fill this survey out all the way to the end. With so many transportation choices available, your responses will help researchers fill in the picture about the choices people make in how to travel around their city.

We realize that people make many different kinds of trips using all kinds of transportation, and that these change depending on many different circumstances--so it might be hard to say what's "typical." As you fill out this survey, just try to think about the journeys you make most often.

If you decide you need to change or review something, you can back up at any time without losing your answers.

When you're ready to get started, please click "Next," below.

Your experience with different forms of transportation

1. Have you ever used a shared form of transportation like bike-sharing, car-sharing, or a ride-sharing service like Uber or Lyft?

- ☐ Yes
- ☐ No

Definitions

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Your experience with shared-use transportation

* 4. Which shared-use service do you use MOST OFTEN? (If you typically use more than one service per trip, choose the one you spend the most time on.)

- ☐ Public bus
- ☐ Public train
- ☐ Bike-sharing
- ☐ Car-sharing
- ☐ Ride-sharing
- ☐ Other shared-use service (please specify)

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Your experience with shared-use transportation (cont.)

5. Thinking about the service you selected in the prior question, how would you make your most frequent trip if that service was not available?

- | | |
|--|---|
| <input type="radio"/> Public bus | <input type="radio"/> Ride-sharing |
| <input type="radio"/> Public train | <input type="radio"/> Walk the whole way |
| <input type="radio"/> Bike-sharing | <input type="radio"/> Drive alone |
| <input type="radio"/> Car-sharing | <input type="radio"/> Drive with family/friend |
| <input type="radio"/> Private bicycle | <input type="radio"/> I wouldn't take this trip |
| <input type="radio"/> Other (please specify) | |

6. In what metro area do you most often make trips by [Q4]?

2. When was the FIRST time you used each form of transportation?

	Last 3 months	3-6 months ago	7-12 months ago	1-5 years ago	More than 5 years ago	N/A
Public bus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Public train	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bike-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Car-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ride-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. When was the LAST time you used each form of transportation? *(Please choose the most recent period when you used each type.)*

	Today or yesterday	Within the last week	Within the last month	Within the last 3 months	Within the last year	1-5 years ago	Never, or more than 5 years ago
Public bus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Public train	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bike-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Car-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ride-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Your experience with shared-use transportation (cont.)

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Driving alone: you driving by yourself in a car owned by your household.

Driving with family/friend: a ride with a friend or family member, regardless of who is driving.

Your experience with shared-use transportation (cont.)

7. How often do you travel in each of these ways?

	Daily or almost daily	1-3 times a week	1-3 times a month	A few times a year	Less than once a year, or never
Public bus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Public train	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bike-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Car-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ride-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving alone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving with family/friend	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If you usually use another form of transport, please list it here, along with how often you use it:

8. If you use them, about how long is your most frequent one-way trip on each form of transportation?

	Under a mile	1-5 miles	6-10 miles	11-20 miles	More than 20 miles	N/A
Public bus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Public train	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bike-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Car-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ride-sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving alone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving with family/friend	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If you usually use another form of transport, please list it here, along with the distance you usually travel on it:

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Driving alone: you driving by yourself in a car owned by your household.

Driving with family/friend: a ride with a friend or family member, regardless of who is driving.

Comparing different forms of transportation (cont.)

9. In the past 3 months, which of the following forms of transportation have you used for each type of trip? (Please select all that apply, and leave blank any you don't use.)

	Getting to or from work/school	Shopping or running errands	Recreation or social events
Public bus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Public train	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bike-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Car-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ride-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Driving alone	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Driving with family/friend	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If you usually use another form of transport, please list it here, along with the trip types you use it for:

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Driving alone: you driving by yourself in a car owned by your household.

Driving with family/friend: a ride with a friend or family member, regardless of who is driving.

Changes since you've started using shared forms of transportation

10. Have you made or noticed any of these changes in your transportation habits since you started using shared forms of transportation? (Check all that apply.)

- | | |
|---|--|
| <input type="checkbox"/> Drove a car more to work | <input type="checkbox"/> Used public transit more |
| <input type="checkbox"/> Drove a car less to work | <input type="checkbox"/> Used public transit less |
| <input type="checkbox"/> Drove a car more for errands or recreation | <input type="checkbox"/> Became more physically active |
| <input type="checkbox"/> Drove a car less for errands or recreation | <input type="checkbox"/> Became less physically active |
| <input type="checkbox"/> Other (please specify): | |

11. Have you or your household made any of these financial changes since you started using shared forms of transportation? *(Check all that apply.)*

<input type="checkbox"/> Postponed purchasing a car	<input type="checkbox"/> Purchased/leased a car to use for peer-to-peer car-sharing
<input type="checkbox"/> Decided not to purchase a car	<input type="checkbox"/> Purchased/leased a car only for private use
<input type="checkbox"/> Sold a car and didn't replace it	<input type="checkbox"/> Spent more on transportation
<input type="checkbox"/> Purchased/leased a car to work as a ride-sharing driver	<input type="checkbox"/> Spent less on transportation
<input type="checkbox"/> Other (please specify):	
<div style="border: 1px solid black; height: 20px; width: 100%;"></div>	

When and why you choose different forms of transportation

12. How would you typically travel to or from your home in these different times and conditions? *(If you'd combine forms of transport, choose the one you would spend the most time on.)*

	Public bus	Public train	Bike-sharing	Car-sharing	Ride-sharing	Driving alone	Driving with family/friend	Other
When the weather is bad	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I'm running late	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I have to be somewhere by a certain time (airport, job interview)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I'm concerned about my safety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When traffic is bad	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When I'm carrying a lot of stuff	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When money is tight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When I lack access to a reliable vehicle	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If you marked "other," please explain:

13. For each type of trip, what makes the single greatest impact on your choice of how to travel?

	Convenience	Cost	Reliability	Weather	Length of trip	How much I'm carrying	Ability to use phone or tablet	Environmental concerns	Traffic	Other
Going to work/school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Shopping, appointments, or running errands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recreation or social events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If you marked "other," please explain:

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Driving alone: you driving by yourself in a car owned by your household.

Driving with family/friend: a ride with a friend or family member, regardless of who is driving.

When you use different forms of transportation

14. At what hours of the day and week do you generally use each form of transportation? (Check as many as apply.)

	Weekdays	Weekends	Early AM (5am-7am)	AM rush (8am-10am)	Mid-day (11am-4pm)	PM rush (5pm-7pm)	Evening (8pm-10pm)	Late night (11pm-4am)	N/A
Public bus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Public train	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bike-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Car-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ride-sharing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Driving alone	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Driving with family/friend	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Definitions

Public bus: buses, streetcars, or trolleys that move in other traffic and make many stops, as well as express buses, bus rapid transit and streetcars that may run express or in their own lane for part of their journey. Also includes ADA paratransit and dial-a-ride.

Public train: light rail, subways and elevated trains, and commuter trains.

Bike-sharing: bicycles available for short-term use, such as Divvy, Social Bicycles, Capital Bikeshare, Hubway, or B-Cycle.

Car-sharing: cars available by the hour, including services like Zipcar or Enterprise, one-way services like car2go, and peer-to-peer services like Getaround or RelayRides. Does not include cars rented for a day or more.

Ride-sharing: on-demand, app-based systems for finding and paying for rides through a private operator, such as Lyft, Uber, or Sidecar. Also known as ridesourcing.

Driving alone: you driving by yourself in a car owned by your household.

Driving with family/friend: a ride with a friend or family member, regardless of who is driving.

Public transit and new transportation technology

15. Many websites or apps show information about public transit schedules and operations. Which of the following activities have you performed for trips in the metro area where you live? ("Third-party"

means tools from somebody other than a transit agency, including websites and apps like Google Maps, MapQuest, RideScout, TransitApp or Moovit.)

	Transit agency app or website	Third-party app or website
See schedules	<input type="checkbox"/>	<input type="checkbox"/>
Map my route	<input type="checkbox"/>	<input type="checkbox"/>
Find the closest bus stop/train station	<input type="checkbox"/>	<input type="checkbox"/>
Find out how long until the next bus/train is arriving	<input type="checkbox"/>	<input type="checkbox"/>
See where transit vehicles are in real time	<input type="checkbox"/>	<input type="checkbox"/>
Reload a farecard or fare account	<input type="checkbox"/>	<input type="checkbox"/>
Pay a fare on a bus or train	<input type="checkbox"/>	<input type="checkbox"/>
Learn previously unknown transit options for getting to a destination	<input type="checkbox"/>	<input type="checkbox"/>
Learn previously unknown non-transit options for getting to a destination	<input type="checkbox"/>	<input type="checkbox"/>

About you and your household

This is the last page of the survey. Your answers to these demographic questions will help us put the rest of your responses in better context, but all of these questions are optional.

16. In what ZIP code is your home located? (enter 5-digit ZIP code; for example, 00544 or 94305)

17. What is your gender?

18. Including yourself, how many people in each age range currently live in your household?

	0	1	2	3	4 or more
Under 18 years	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18-25	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26-44	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
45-64	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
65+	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

19. How many cars does your household own or lease?

- ☐ None
☐ 1
☐ 2
☐ 3
☐ 4 or more

20. How many bicycles does your household own?

- ☐ None
☐ 1
☐ 2
☐ 3
☐ 4 or more

21. What is your age?

- ☐ 18 to 24
- ☐ 25 to 34
- ☐ 35 to 44
- ☐ 45 to 54
- ☐ 55 to 64
- ☐ 65 to 74
- ☐ 75 or older

22. What was your total household income last year?

- ☐ \$0 to \$24,999
- ☐ \$25,000 to \$49,999
- ☐ \$50,000 to \$74,999
- ☐ \$75,000 to \$99,999
- ☐ \$100,000 to \$124,999
- ☐ \$125,000 or more

Thank you

You're done!

The Shared-Use Mobility Center thanks you for taking the time to fill out this survey. The results of this research will become available over the next few months. Here are several ways to keep up with our work in the meantime:

- Visit the Shared-Use Mobility Center's [website](#)
- Follow us on social media: [Twitter](#) | [Facebook](#) | [Flickr](#)
- [Sign up](#) for our monthly [newsletter](#)

Appendix D: Ridesourcing and Transit Travel Time Comparison

While demand and capacity tell one story, another method of analysis that might better reflect the customer experience with ridesourcing versus transit is to compare the time and cost of traveling similar routes at different times of day. An exploratory analysis of this kind for the Chicago region compared representative travel times for various trip types, including routes along the radial spokes of the train and highway systems, crosstown surface trips in congested corridors, circumferential trips along the suburban periphery, and short first/last mile trips from transit terminals. (Figure D-1) The initial methodology was to simply collect the estimated driving and transit travel times for several routes and several departure times from the Google Maps trip planning tool, along with an estimated cost for that trip from the Uber API, using the UberX class of service. To the driving time we added the average wait time for a pickup in Chicago, using the estimated wait time data collected during the earlier scrape of the Uber API. Results of this exploratory analysis are show below.

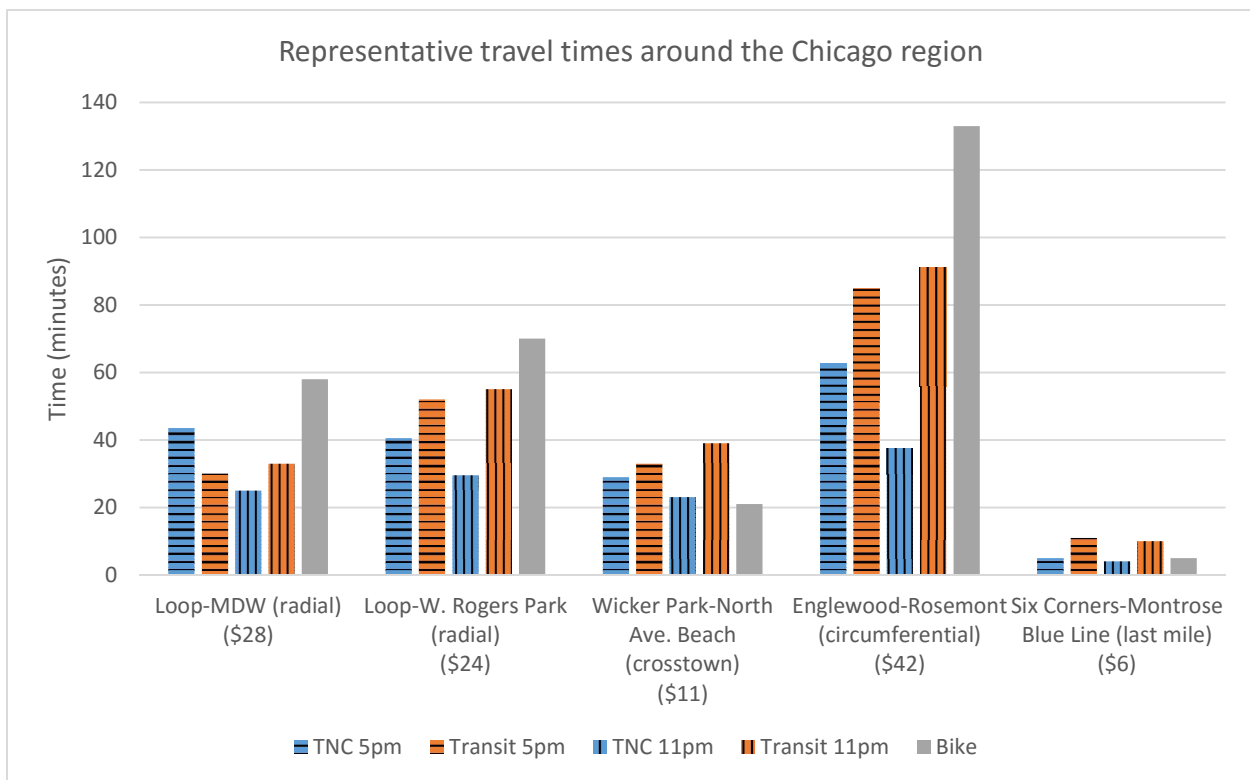


Figure D-1: Representative travel times around the Chicago region, by scheduled transit and ridesourcing, at 5pm and 11pm. Dollar amounts in parentheses show estimated trip cost using UberX service, from Uber API. Data sources: Google Maps (travel times), Uber API (estimated wait times and trip costs).

The initial analysis suggested that at peak hours, fixed-guideway trips are generally the fastest and least expensive in the corridors where they are available. At other times of day, the marginal difference in duration between train and ridesourcing trips would make it difficult for many riders to justify the much higher cost of ridesourcing based on time alone. For other trips, especially crosstown or circumferential

ones involving multiple bus routes, the time advantage of ridesourcing was larger, and was amplified outside of peak hours when drive times are lower and transit times are longer. The cost portion of this analysis was based on “traditional,” single-rider ridesourcing. In cities where ride-splitting versions of the service is available, ridesourcing may become more economical, and could in some places be competitive to transit in both time and cost to riders. These routes, in particular, represent the places where transit agencies might find opportunities to shed low-ridership bus routes in favor of dynamic demand-responsive service or partnerships with shared mobility providers.

For a broader analysis using the same general approach, we used another Google tool, the Distance Matrix API, which allows large-scale automated queries of their directions system, returning a matrix of optimal travel times for different modes from a common origin but with multiple end points. Driving times are based on historical traffic conditions for a given day and hour, and transit directions are based on scheduled service, in each case producing an optimal route that attempts to minimize travel time.

For all of the study regions, we determined an origin address within the highest-employment census block group in each region. We programmatically queried the system for travel times by car and by transit from the single origin to destination points on a half-mile grid over the core county of each study region, for both 5pm and midnight. Given the two modes travel times to each point, we calculated a “travel time ratio,” which is the ratio of transit travel time to a derived “TNC travel time,” using the driving time figure plus average regional wait time for that hour, as obtained earlier from the Uber API (see Appendix E). Plotted on a map, these points give a quick overview of the tradeoffs between different modes at a regional level, as well as showing where transit is simply not an option for a given route. Though these maps show travel between the central business district and the rest of the region, the same approach applied to a number of different origins could reveal much about the mobility picture of a given region.

The maps on the following pages (Figures D-2 through D-8) show the ratio of estimated transit travel time to estimated driving time (in typical traffic, plus mean TNC wait time for the departure hour and region) from a single origin to each of a 0.5 mile grid of core-county destinations. Ratios lower than 1.0 (green colors) mean that transit is faster for a given trip (the darker the green, the greater transit’s time advantage), and ratios higher than 1.0 (yellow to red colors) mean that ridesourcing is faster.

Points shown as only a black dot represent areas for which no ratio could be calculated because either a) no transit route exists between the origin and destination; or b) they represent points with no public roads, such as airports, gated subdivisions or undeveloped areas.

While the specific findings emerging from this analytical approach vary from city to city, a few patterns emerge:

- Peak hour traffic congestion tips the scales in favor of transit that travels in its own right of way—on tracks above or below traffic, or in dedicated lanes.
- Long transit headways at night, along with easier travel on largely congestion-free streets, mean that TNCs are the faster mode for many destinations; but cost remains a key determinant of whether this is actually a viable choice for frequent trips.

- In a few places (central Austin and Seattle, for instance), certain trips are faster on transit late at night than at rush hour--reflecting how congestion blocks the effectiveness of transit running in mixed traffic.

Also note that the maps do not account for the differing cost of rides on transit versus TNCs. As distances increase--and costs with them--it is likely that for most users, the appeal of even a relatively faster TNC ride would drop significantly beyond a certain cost threshold. For occasional trips this might not be a central consideration, but for more frequent trips these costs would be unsustainable. For many trips in these areas, the personal automobile is likely to remain as the mode that maximizes utility for the individual traveler, until some combination arises of a) wider coverage of more frequent transit or b) much lower cost TNC services, such as shared ride services.

Sources: Google Maps Distance Matrix API (transit and driving time estimates), Uber API (TNC wait time), US Census Bureau TIGER/Line (geography).

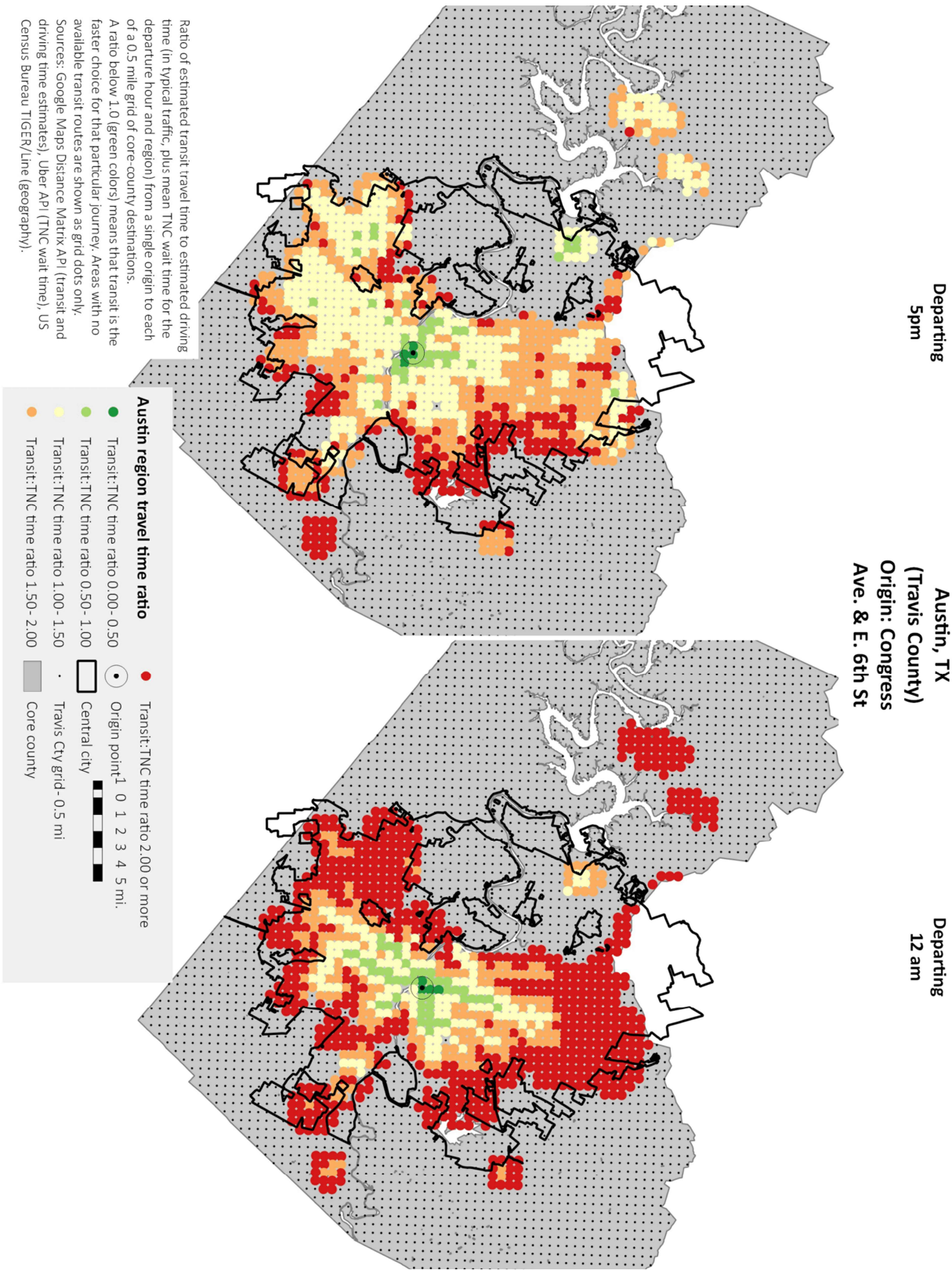


Figure D-2: Transit-TNC travel time ratio, 5pm and midnight, Austin, TX.

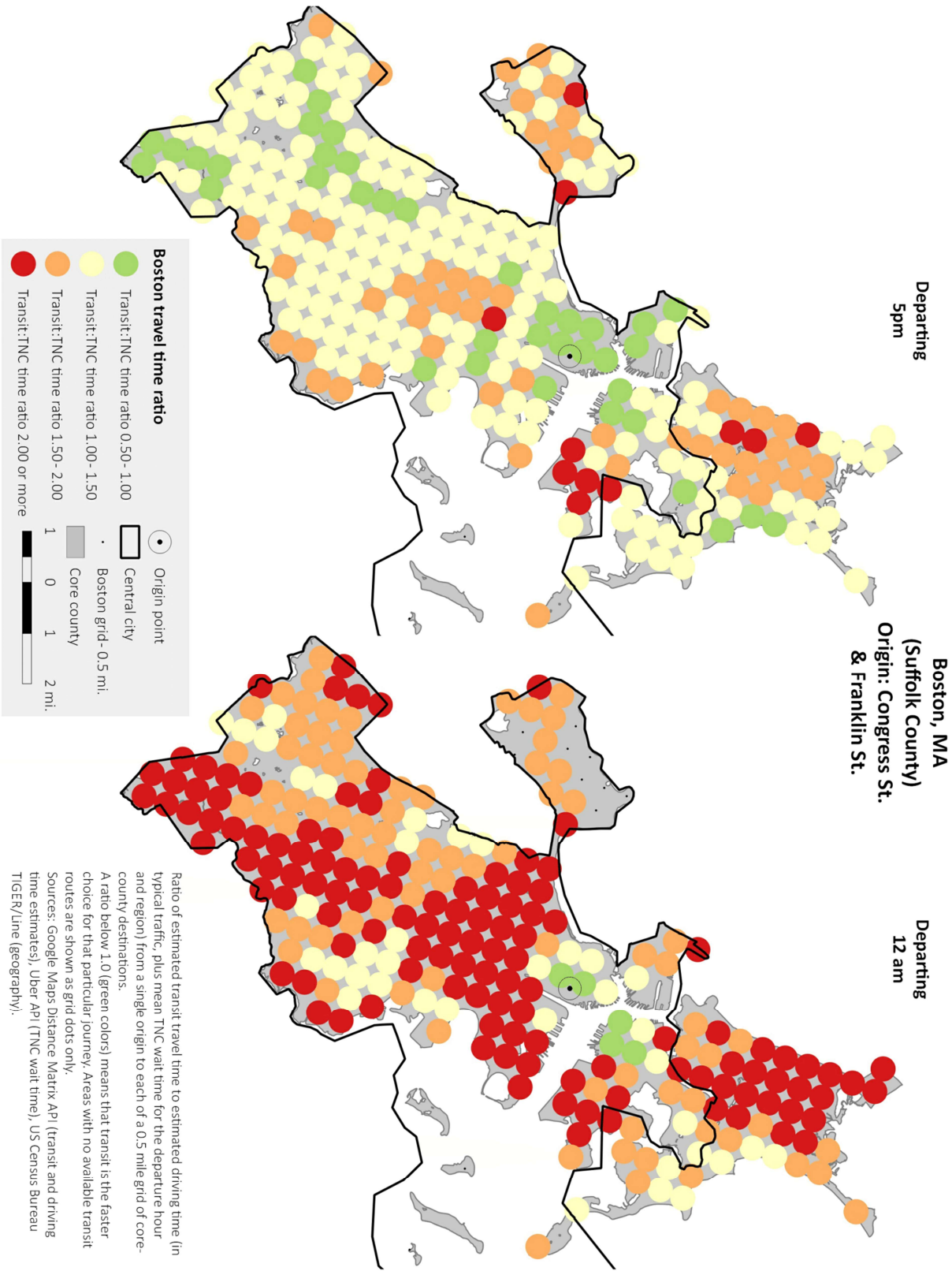


Figure D-3: Transit-TNC travel time ratio, 5pm and midnight, Boston MA.

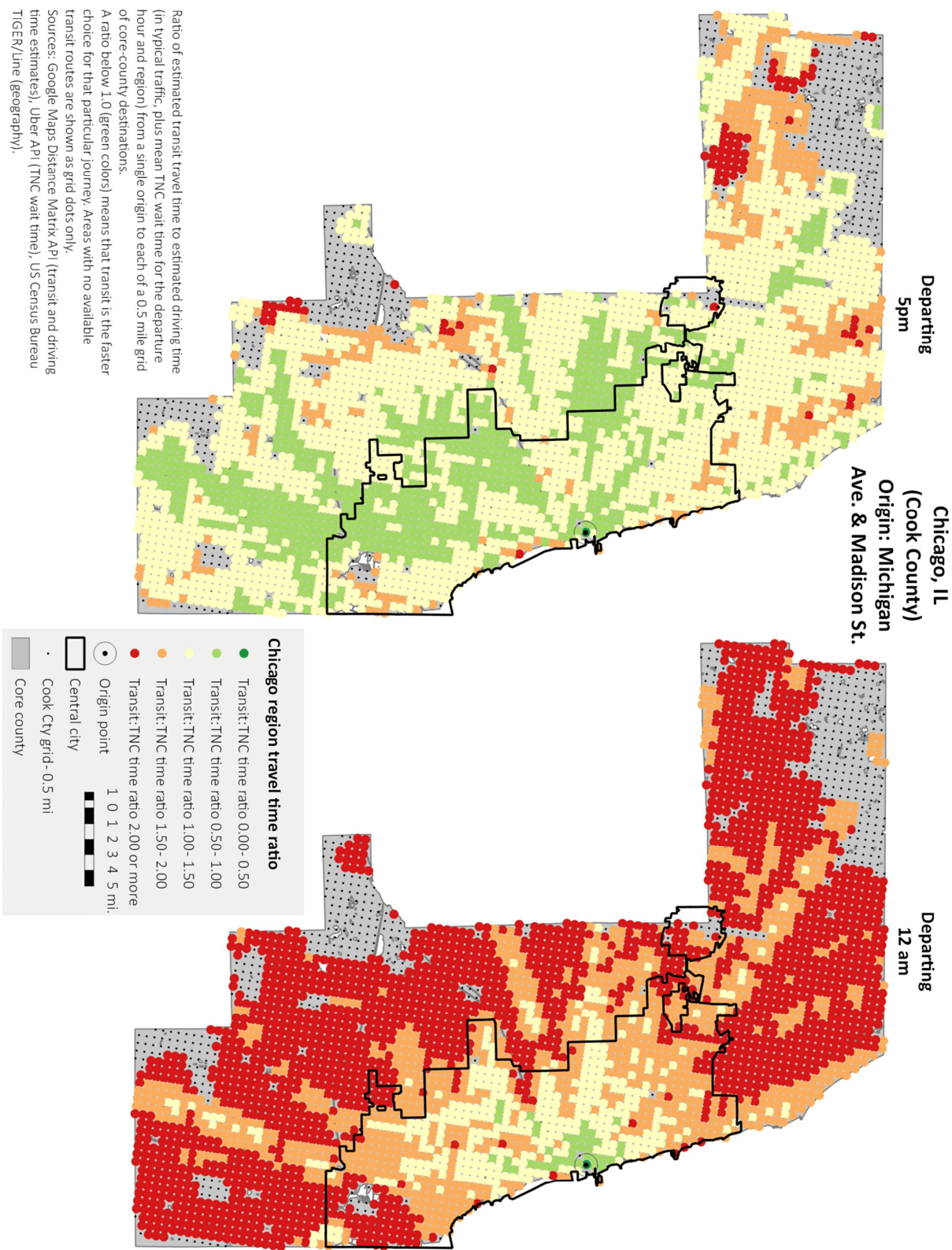


Figure D-4: Transit-TNC travel time ratio, 5pm and midnight, Chicago, IL.

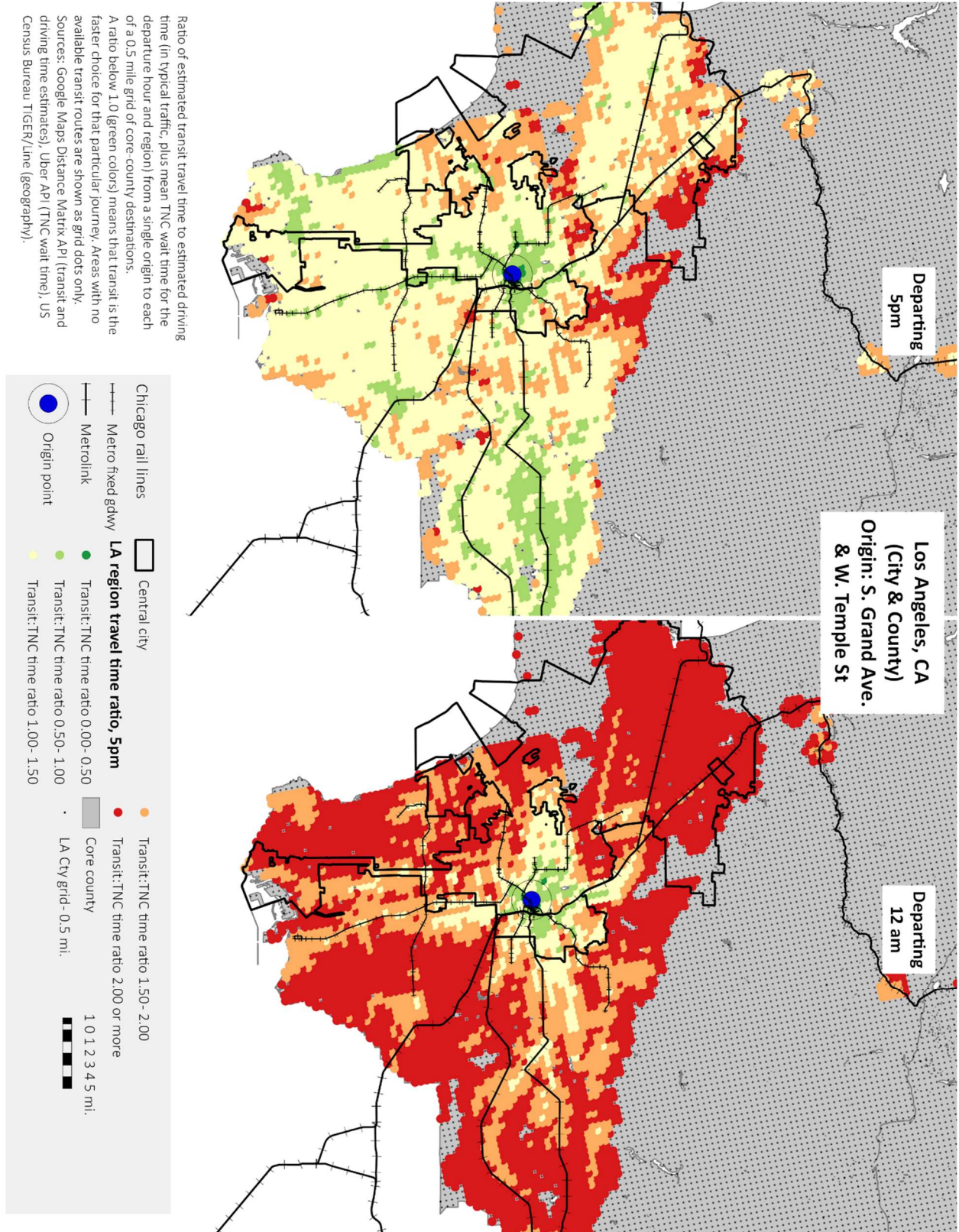


Figure D-5: Transit-TNC travel time ratio, 5pm and midnight, Los Angeles, CA.

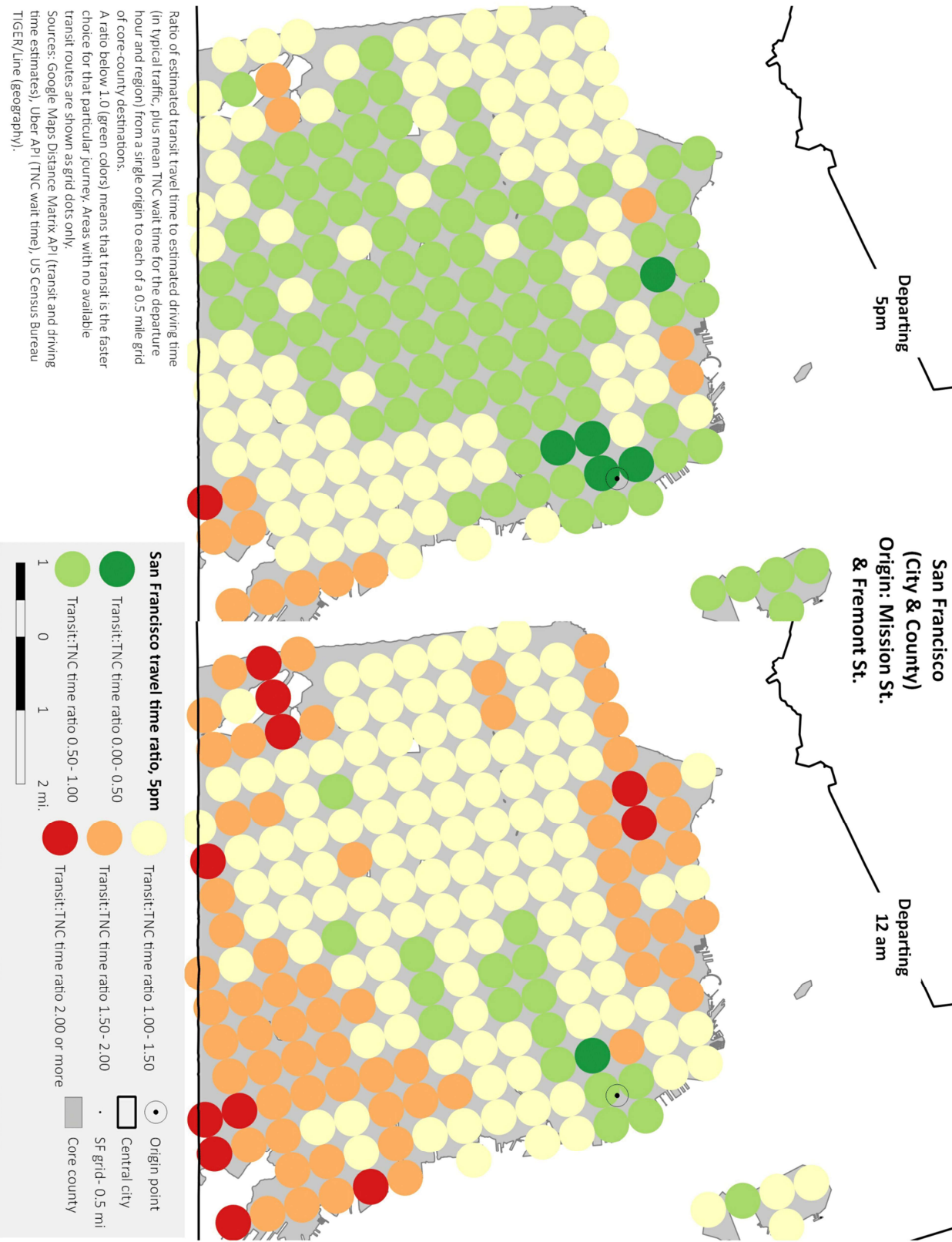


Figure D-6: Transit-TNC travel time ratio, 5pm and midnight, San Francisco, CA.

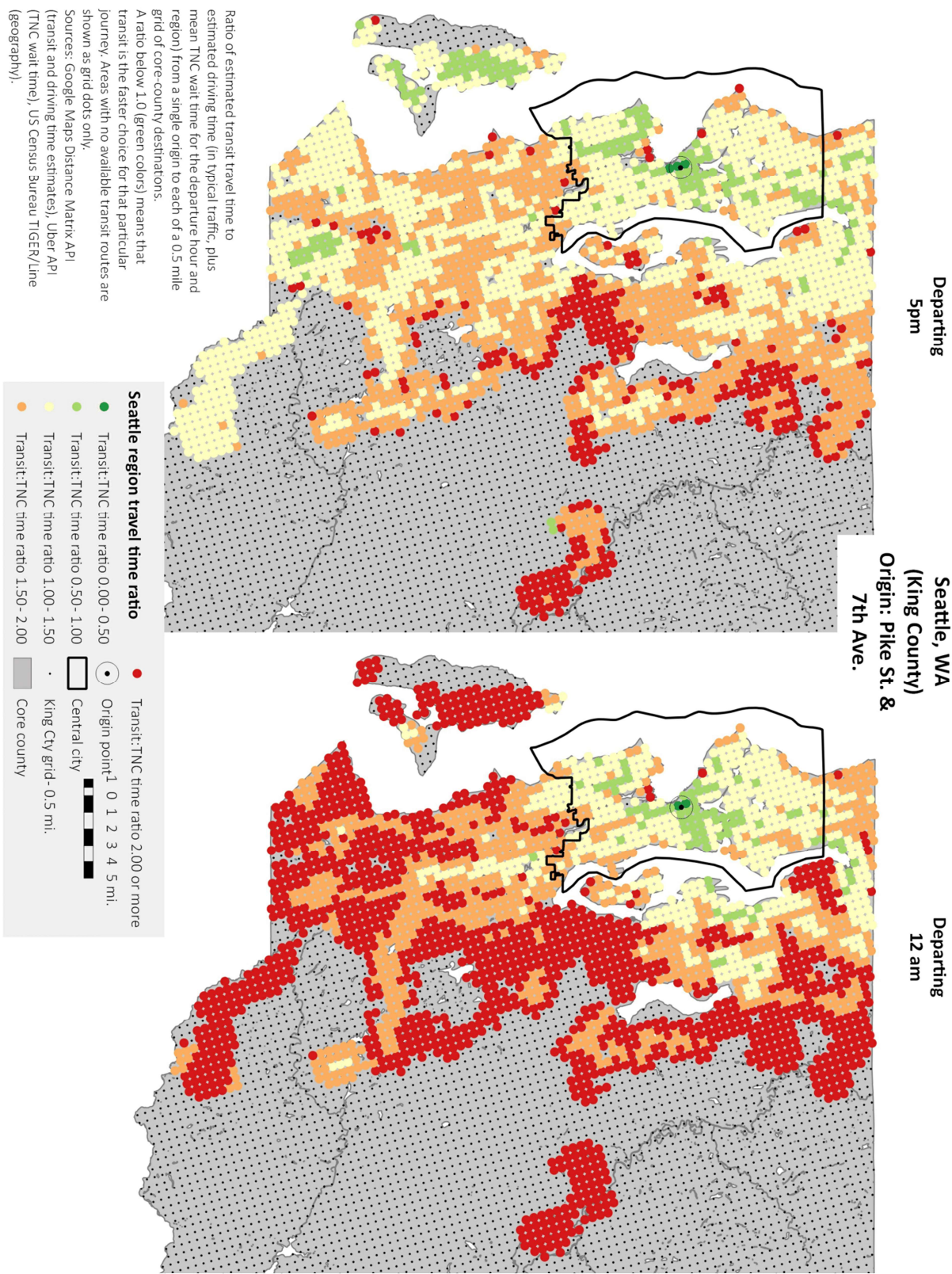


Figure D-7: Transit-TNC travel time ratio, 5pm and midnight, Seattle, WA.

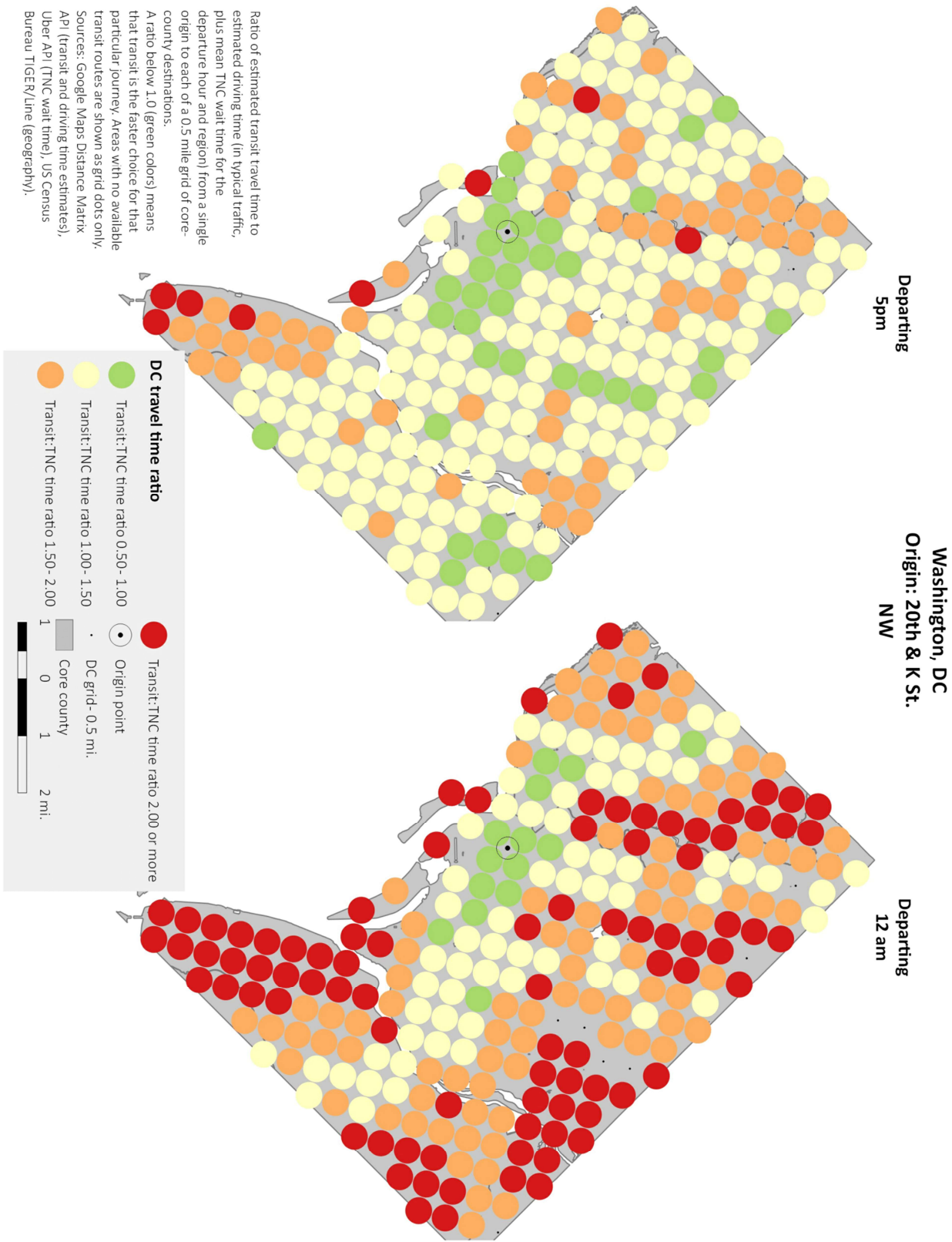


Figure D-8: Transit-TNC travel time ratio, 5pm and midnight, Washington, DC.

Appendix E: Ridesourcing Demand and Transit Capacity Calculation

Overview of data collection from Uber API

For proprietary reasons, ridesourcing companies are extremely protective of their actual trip data, and the researchers were unable to secure an anonymized or aggregated set of trip data for this phase of the study from either of the two largest ridesourcing companies, Uber or Lyft. However, Uber does provide a way to request information about their services via their application protocol interface (API), a portal where two computers can pass specific information back and forth in a structured way. In the case of the Uber API, a client computer can ask the API for a cost and time estimate for a ride between a specific origin and destination at that moment in time. Queries from the Uber smartphone app use the API to get information, request rides, and interact with their account; Uber also provides documentation of and limited access to the API to third-party software developers.

Uber granted the researchers access to their API for a limited number of requests per hour (1000 each of time and price). All of the queries we made were to a purely informational portion of the API, which did not generate actual ride requests or spoof calls for service. By systematically querying the API throughout the day and week, feeding it origin/destination pairs from specific points providing coverage of our study cities, we gradually assembled a picture of how ridesourcing availability and demand varies across time and geography.

The response from the Uber API contains several potentially interesting data points, among which the most useful for purposes of inferring supply and demand are an estimated time in minutes before an Uber car could reach the origin point, and a price estimate, which includes a component called the surge multiplier, a factor applied to the base price of a ride at times when demand for rides is high in a specific area. Because surge multipliers are limited in time and in geography, and because they vary along a scale from 1 to more than 6 (which means a rider would pay 6 times the base price), they can tell us something about the relative level of demand at a given point and time.

For each study city, we chose to limit the geographical extent of our queries to Census tracts constituting the core county of each metro area. With tract counts ranging from 180 (DC) to more than 2300 (Los Angeles) we would be unable to query the full extent of our regions at the tract level every hour. Instead we chose to employ a weighted random sampling method for an initial four-week round of data collection, and for a second four-week round narrowed the view to four core counties that were able to be fully covered every hour (Austin, San Francisco, Seattle, and Washington DC).

To collect the data, we built a set of scripts in the R and Python computer languages that did the following:

1. For each metro geography, we built files with tract-level counts of a variety of Census variables, by which we weight the random tract selection for the next step.
2. Each hour, query the Uber API for estimated wait time and price for each of 1000 theoretical trips in the study cities, and store the responses for later analysis.

Combined, the two rounds of collection produced some 1.07 million usable observations for the study regions.

Scheduled transit capacity from GTFS

To determine how Uber rides corresponded with transit trips, the researchers compared the Uber data with agencies' General Transit Feed Specification (GTFS) service information. For the transit capacity side of the comparison, we started from the assumption that the transit agencies schedule service in accordance with customer demand, and used the GTFS schedule data to build estimates of service capacity at the zip code level across the day and week. The researchers were assisted in assembling the transit capacity analysis by our partners at Sam Schwartz Engineering, who gathered all relevant transit agencies' GTFS feeds and programmatically transformed it to hourly counts of trips, vehicles and vehicle types, and maximum wait times for each stop in the system (limited, like the ridesourcing data, to the core county of each region). Using standard load factors and agency-specific vehicle sizes to estimate capacity at each stop, we arrived at a measure of seat-stops per hour for each stop; schedule information allowed us to calculate typical headways at each stop. We then assigned each stop to its containing zip code and generated aggregate measures of seat stops per hour and average headways at the zip code tabulation area (ZCTA) level. Because of differences in how individual agencies convert their operation schedules into GTFS (WMATA's feed in particular has a number of unusual features), cross-agency comparisons based on this data should be approached with caution, especially for more sensitive statistical analyses. However, in aggregated form, the data do serve to usefully illustrate the fluctuation in scheduled service levels across the day and week.

Summary maps of the transit and ridesourcing data are in Appendix F.

Validity of surge pricing as a demand indicator

Though Uber readily acknowledges that surge pricing is their system's way of signaling high demand to both drivers and customers, we validated our interpretation of this indicator by comparing our own additional scrape of these data for Brooklyn, New York, to trip data released by the New York City Taxi and Limousine Commission (TLC). While the samples were not concurrent (the TLC data covered the period January-June 2015, while the API data was collected between October and December 2015), they do show contours in their hourly and daily fluctuations that resemble both one another and the surge pricing patterns in the seven study cities, with the highest use at weekend late nights and moderate rush hour peaks on weekdays (the two sources are shown in Figure E-1 **Error! Reference source not found.**). While the surge data showed less range than in other cities and fit was far from perfect, statistical modeling showed that the surge multiplier, day of week, and hour of the day were fairly strong predictors the actual rider count. The surge multiplier tended to overestimate the weekday demand, while moderating the weekend nights somewhat, but the overall pattern remained. Possible explanations for these differences are differing seasonality of the data, actual changes in trip patterns, or that the surge multiplier is a better predictor of demand in a particular location than for a large area.

Shared Mobility and the Transformation of Public Transit
Appendix E: Ridesourcing demand and transit capacity calculation

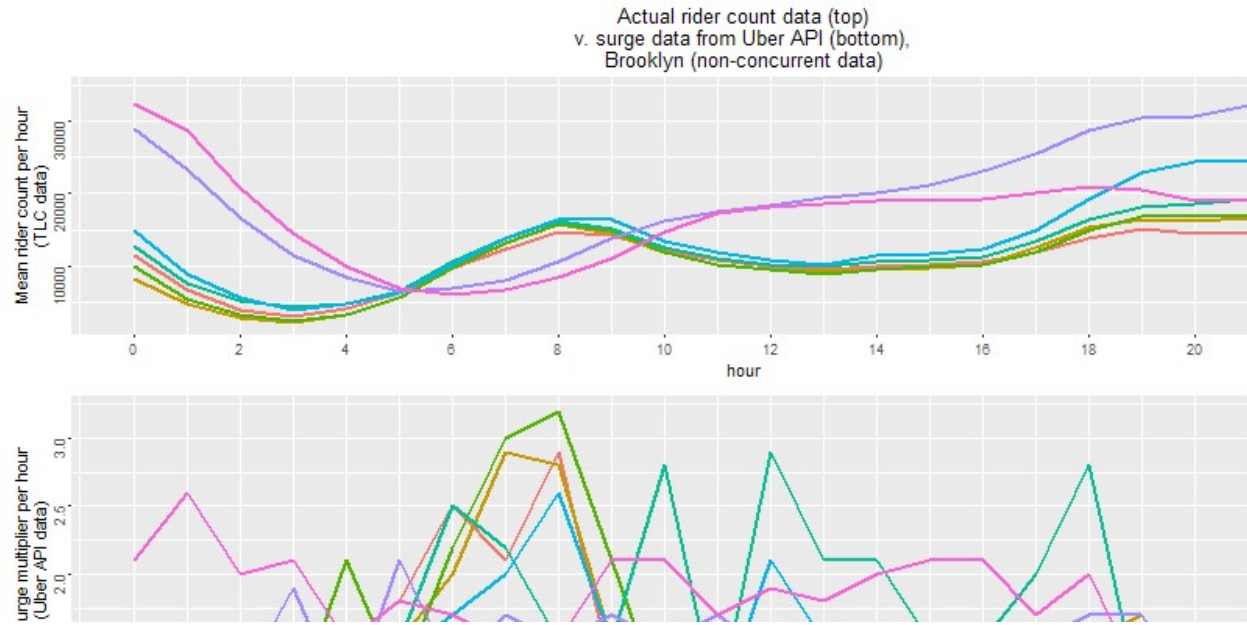


Figure E-1: TNC rider count data from New York City Taxi and Limousine Commission trip reporting (top) vs. surge multiplier data from Uber API (bottom), for locations covering Brooklyn. The data are not concurrent: the TLC data covered the period January–June 2015, while the API data were collected between October–December 2015.

Appendix F: Maps of Ridesourcing and Transit Demand and Capacity

The maps in this section (Figures F-1 through F-21) depict estimates of scheduled public transit capacity and wait time alongside indicators of ridesourcing demand and capacity derived from queries of the Uber API, with data aggregated to the zip code (ZCTA) level. The methodology is described in Appendix E.

For each of the seven study cities, maps are shown for the weekday morning peak (7-10am), afternoon peak (4-7pm), and weekend late night periods (10pm-3am). Each figure displays the following data at the ZCTA level for each time period:

Scheduled transit (left-hand maps)

- Seat-stops per hour (number of stop locations * number of stop events * vehicle capacity), represented by the depth of the red color gradient
- Average wait time in minutes (headway), represented by the direction of crosshatching

Ridesourcing (right-hand maps)

- Average wait time in minutes, shown by the depth of the green color gradient
- Maximum surge multiplier, represented by the direction of crosshatching

Data sources: Transit agency GTFS feeds (transit data), Uber API (ridesourcing data), US Census TIGER/Line (geography).

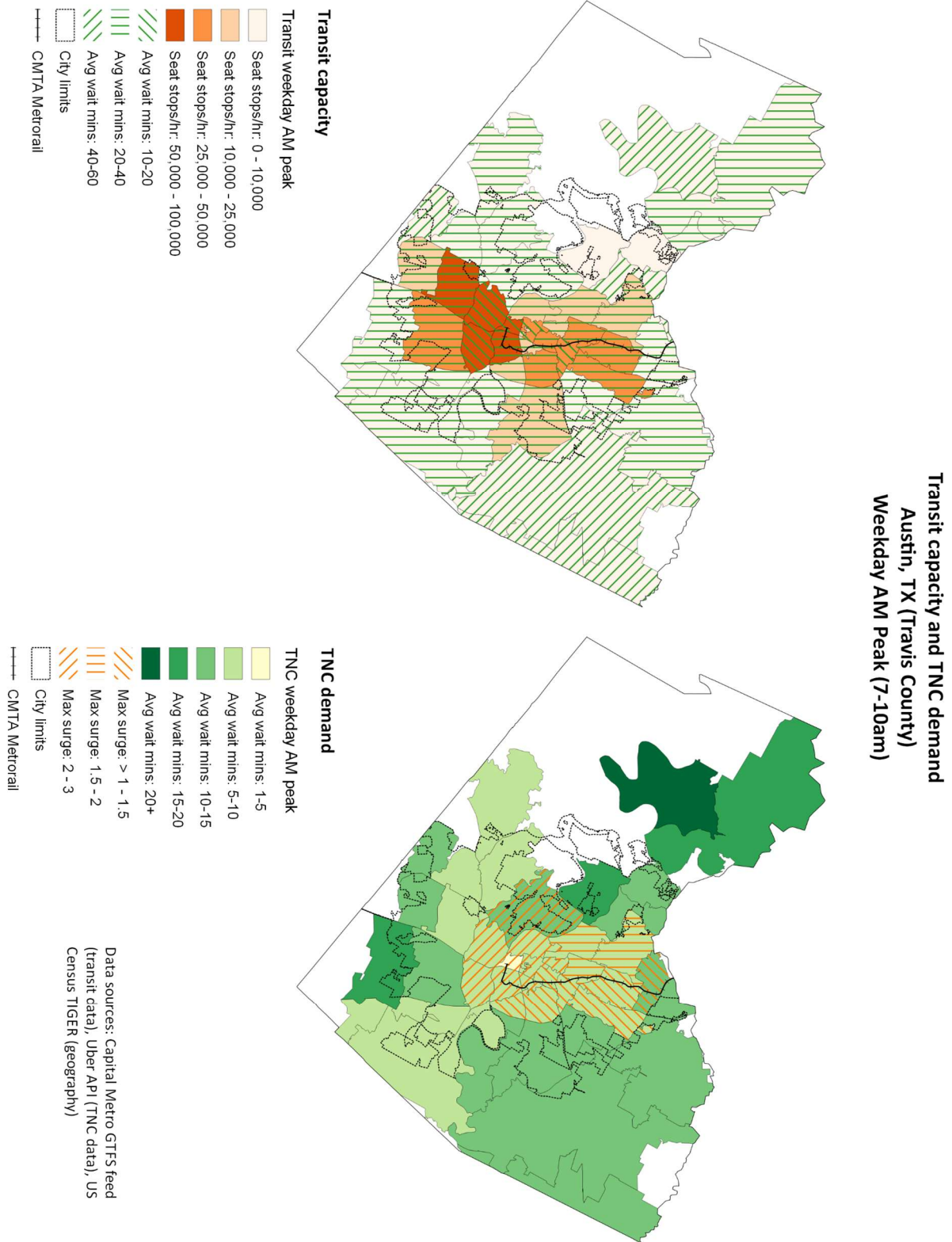


Figure F-1: Transit capacity and TNC demand, Weekday AM peak, Austin TX

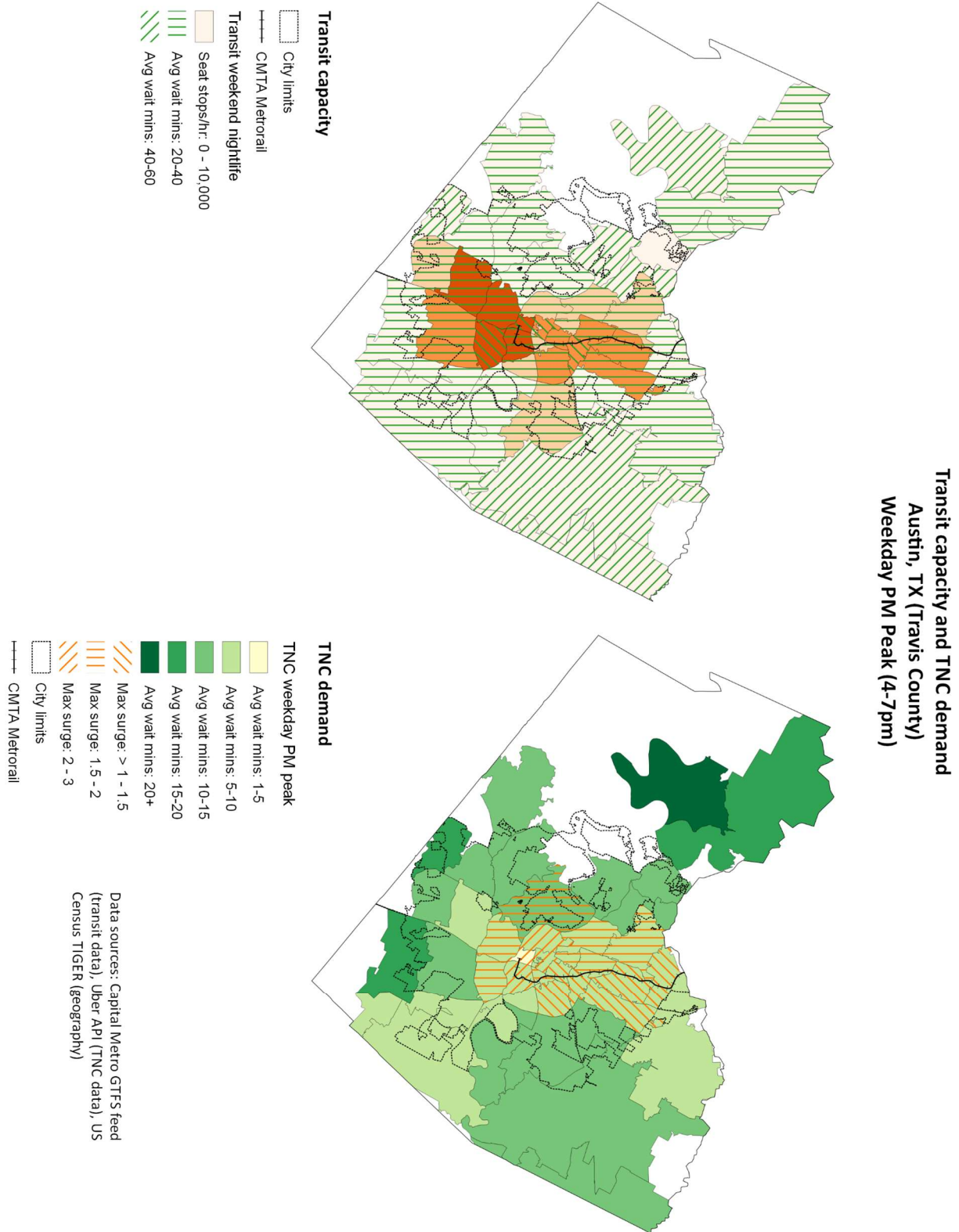


Figure F-2: Transit capacity and TNC demand, Weekday PM peak, Austin TX

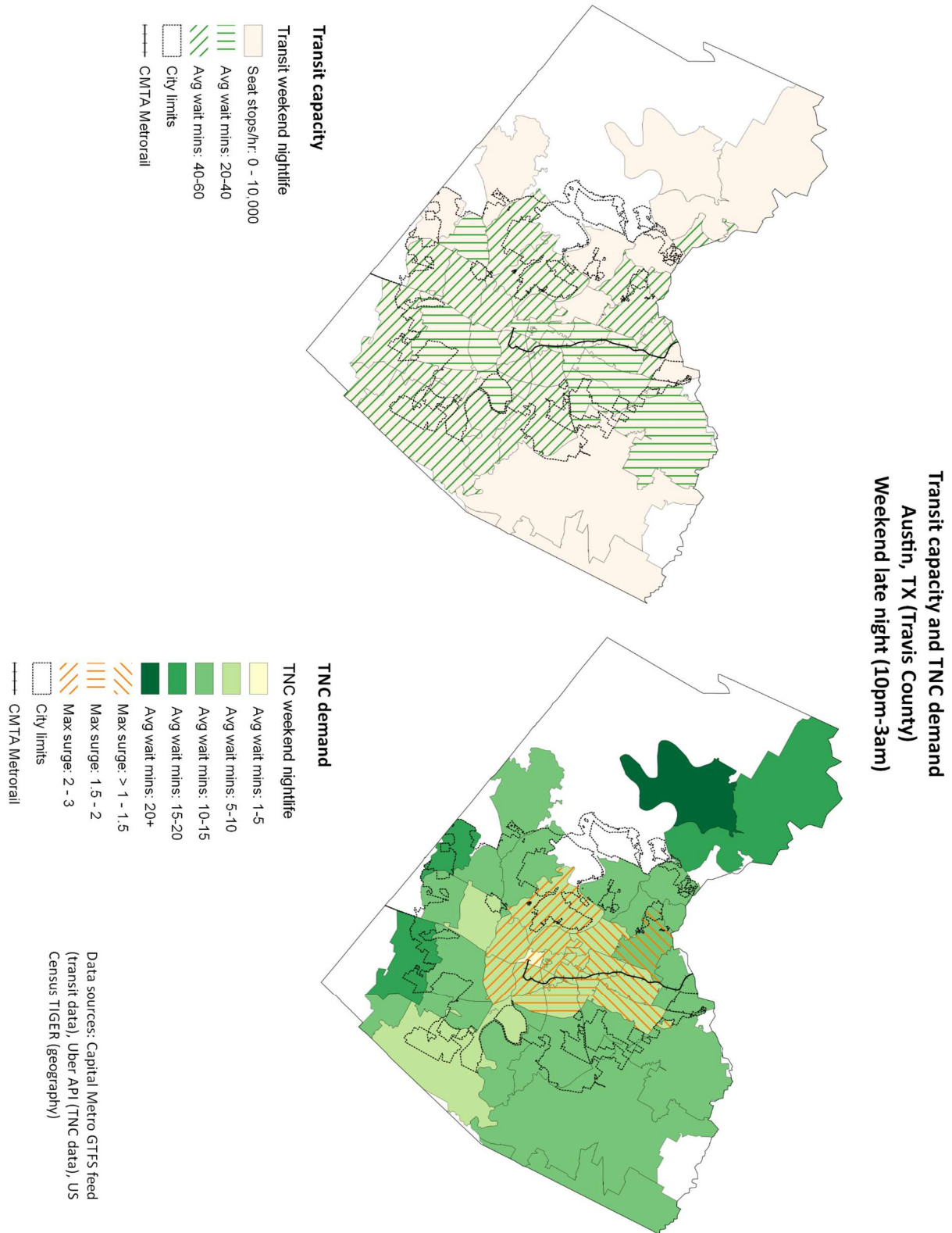


Figure F-3: Transit capacity and TNC demand, Weekend late night, Austin TX

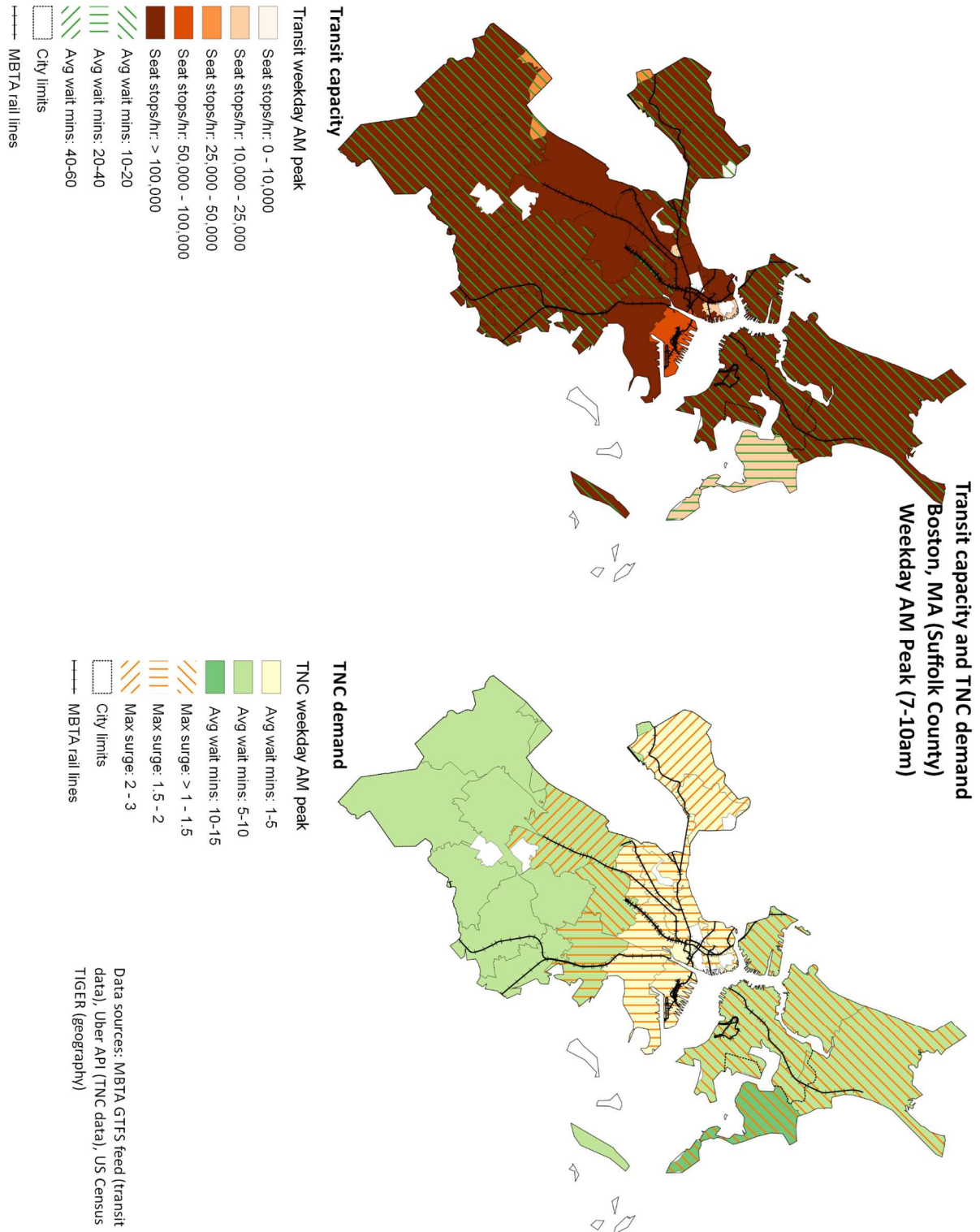


Figure F-4: Transit capacity and TNC demand, Weekday AM peak, Boston MA

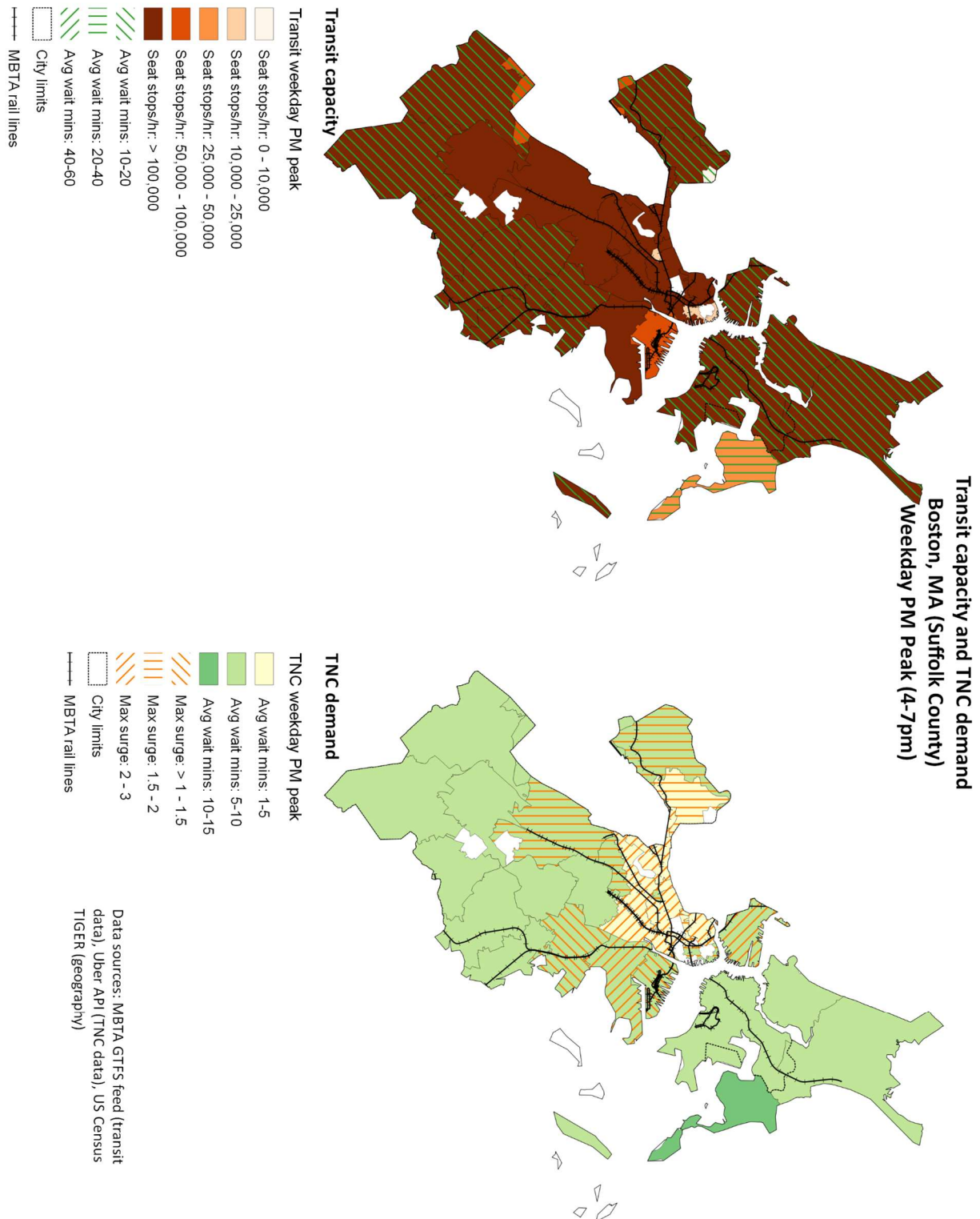


Figure F-5: Transit capacity and TNC demand, Weekday PM peak, Boston MA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

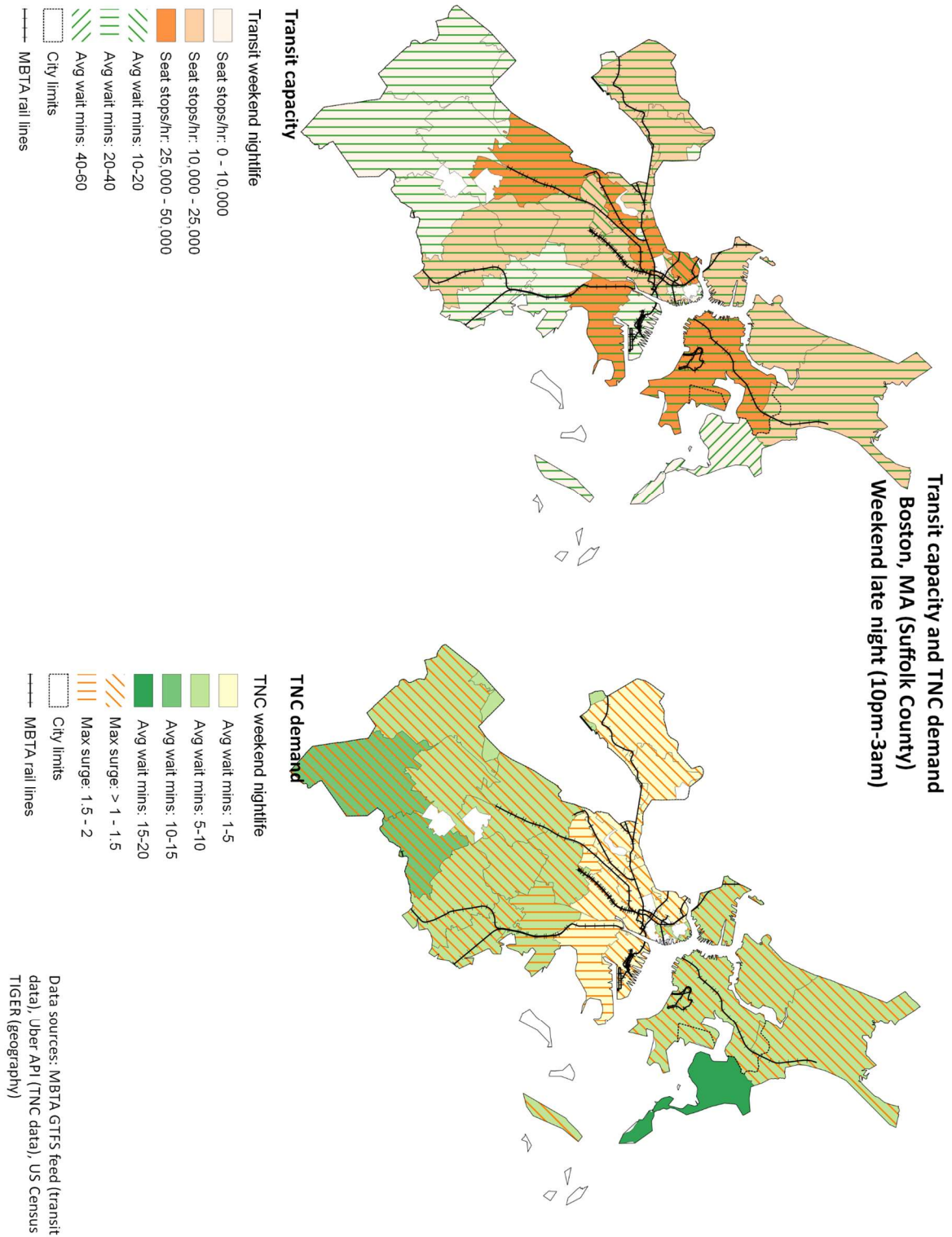


Figure F-6: Transit capacity and TNC demand, Weekend late night, Boston MA. Boston transit data do not reflect March 2016 cuts to late-night MBTA service.

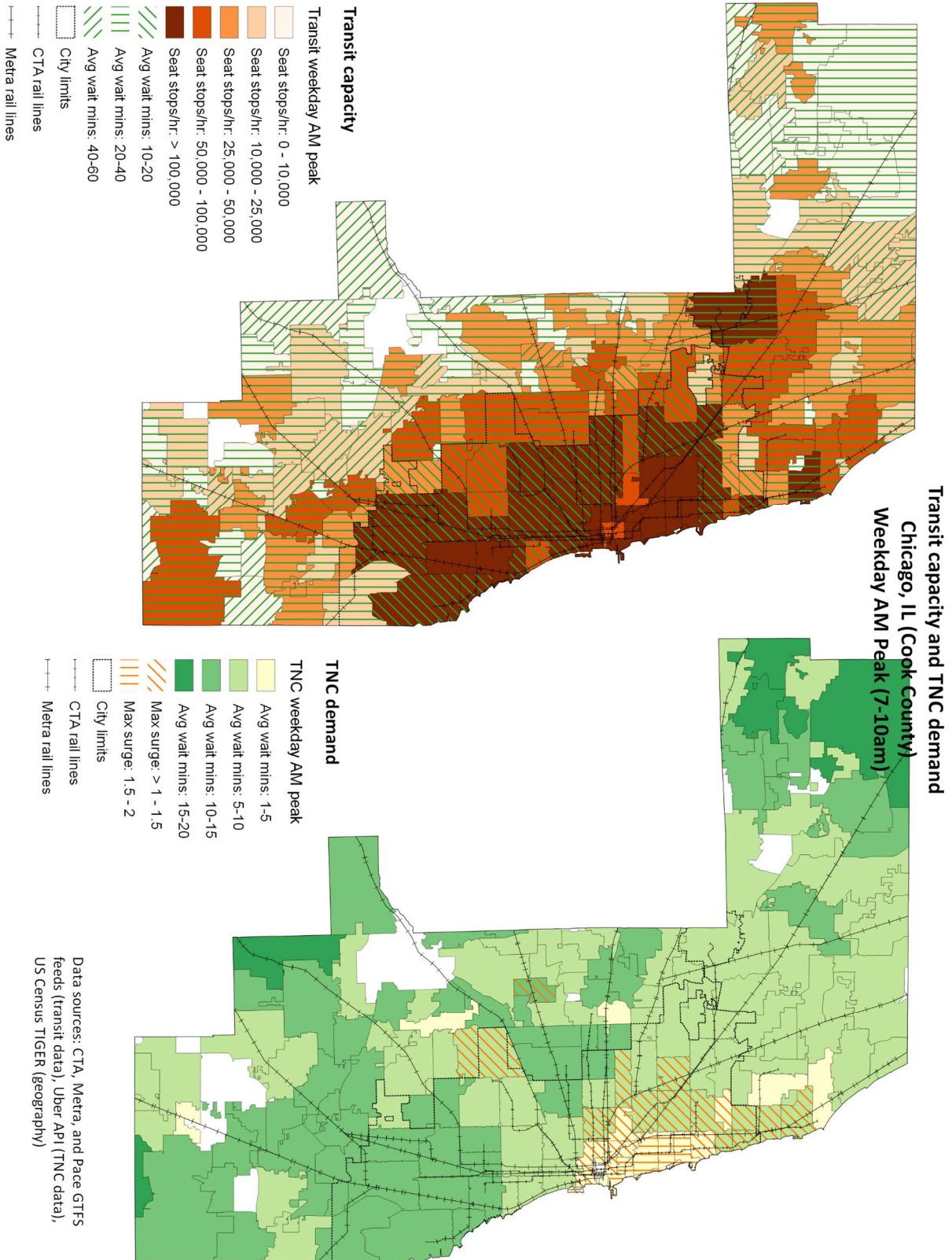


Figure F-7: Transit capacity and TNC demand, Weekday AM peak, Chicago IL

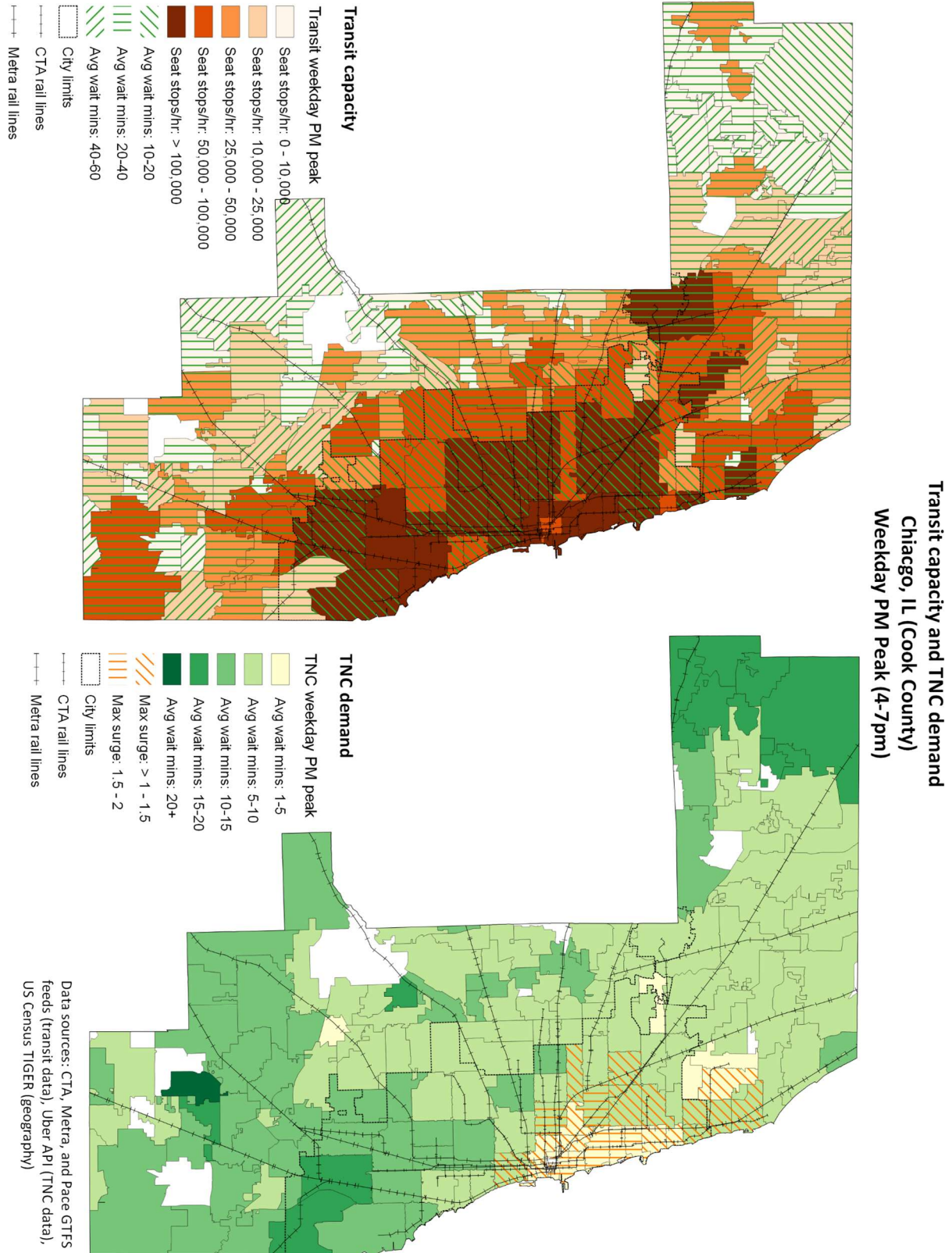


Figure F-8: Transit capacity and TNC demand, Weekday PM peak, Chicago IL

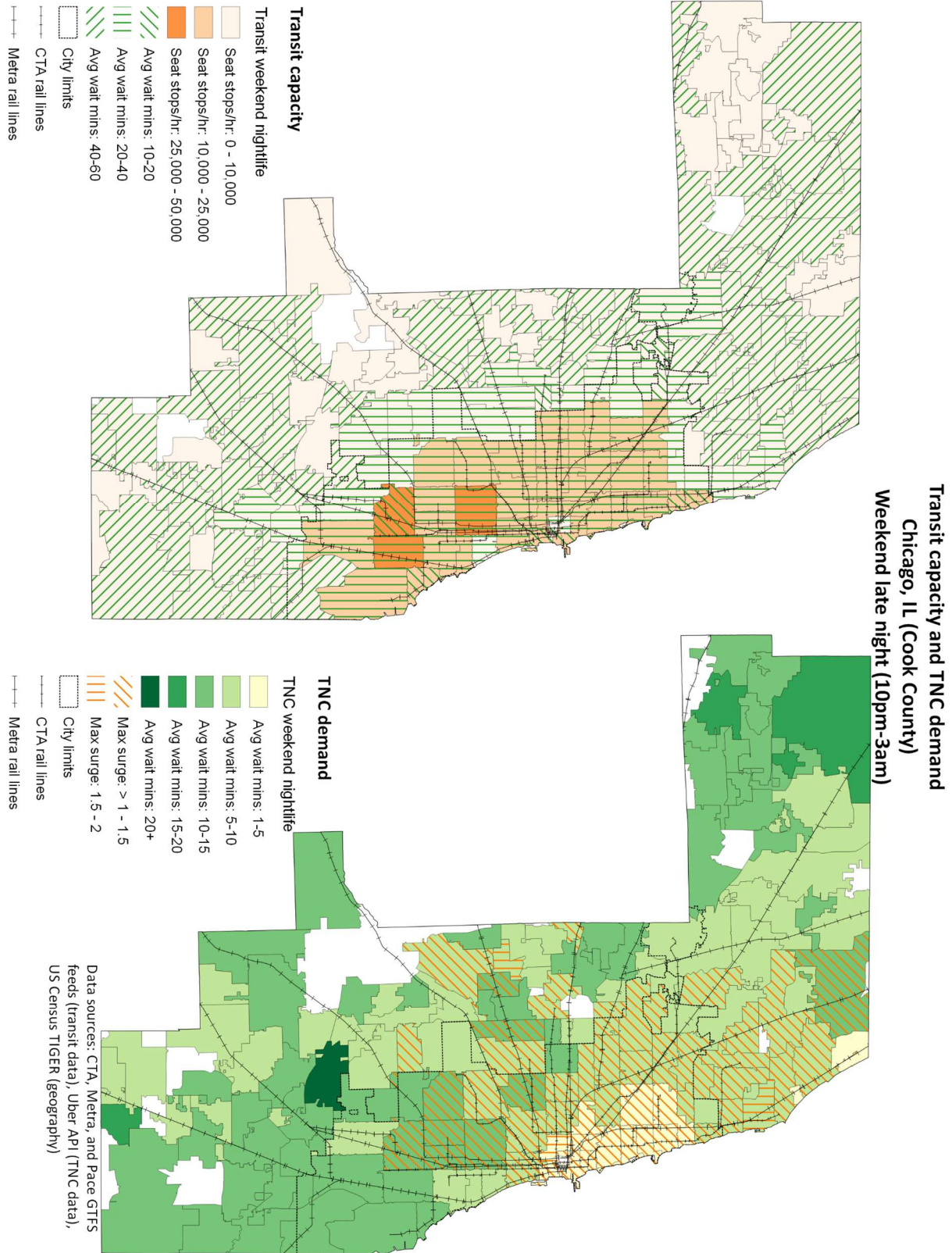


Figure F-9: Transit capacity and TNC demand, Weekend late night, Chicago IL

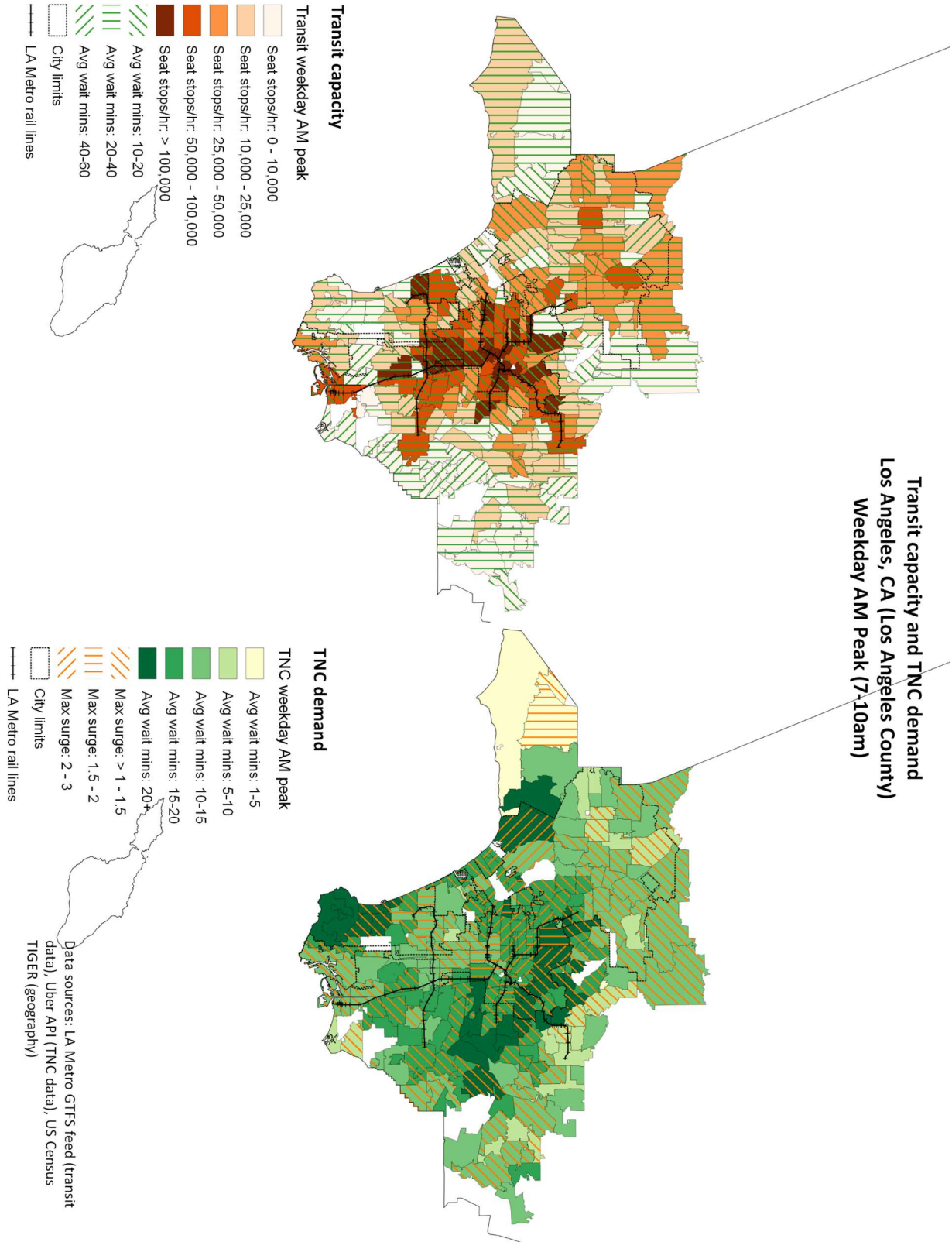


Figure F-10: Transit capacity and TNC demand, Weekday AM peak, Los Angeles CA

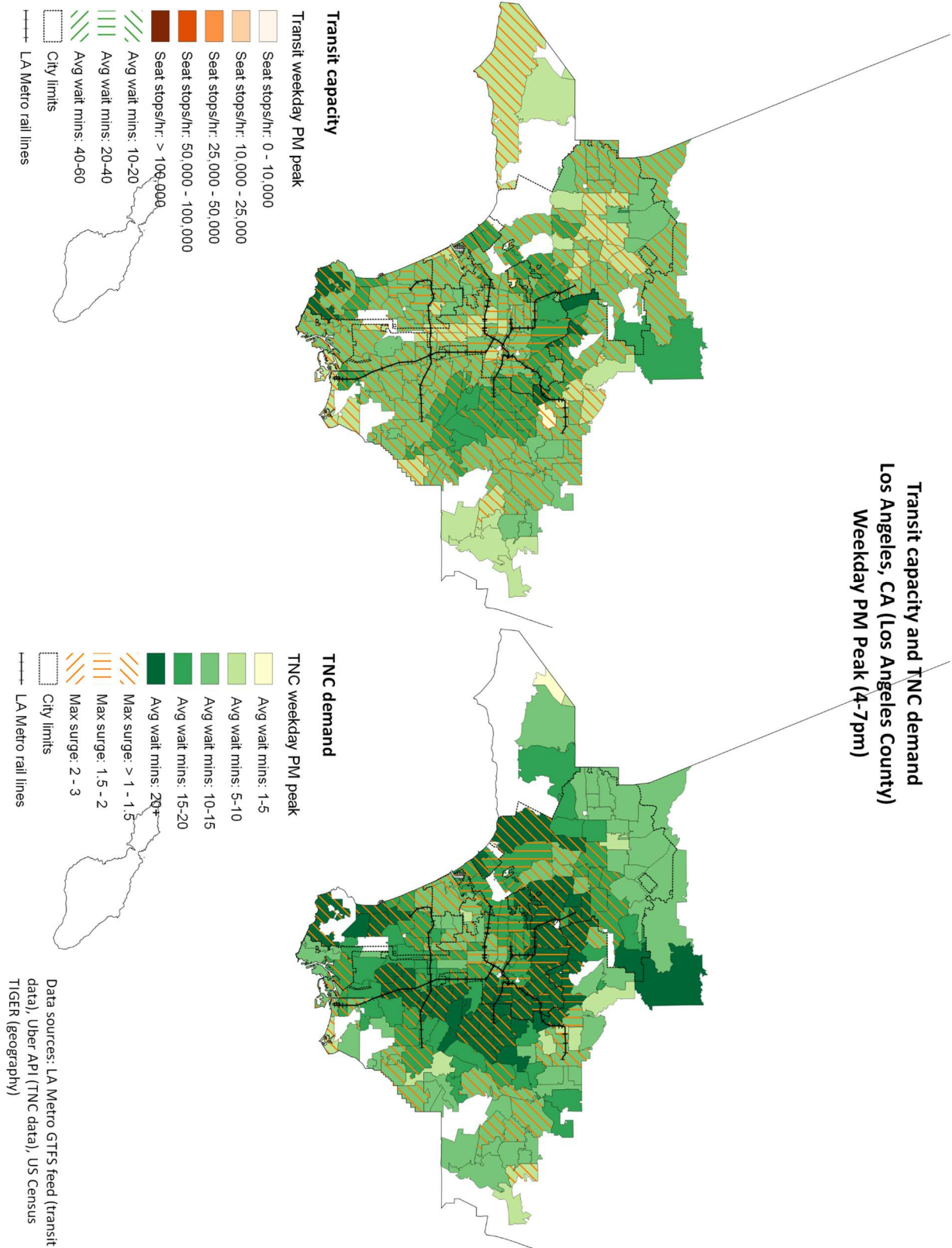


Figure F-11: Transit capacity and TNC demand, Weekday PM peak, Los Angeles CA

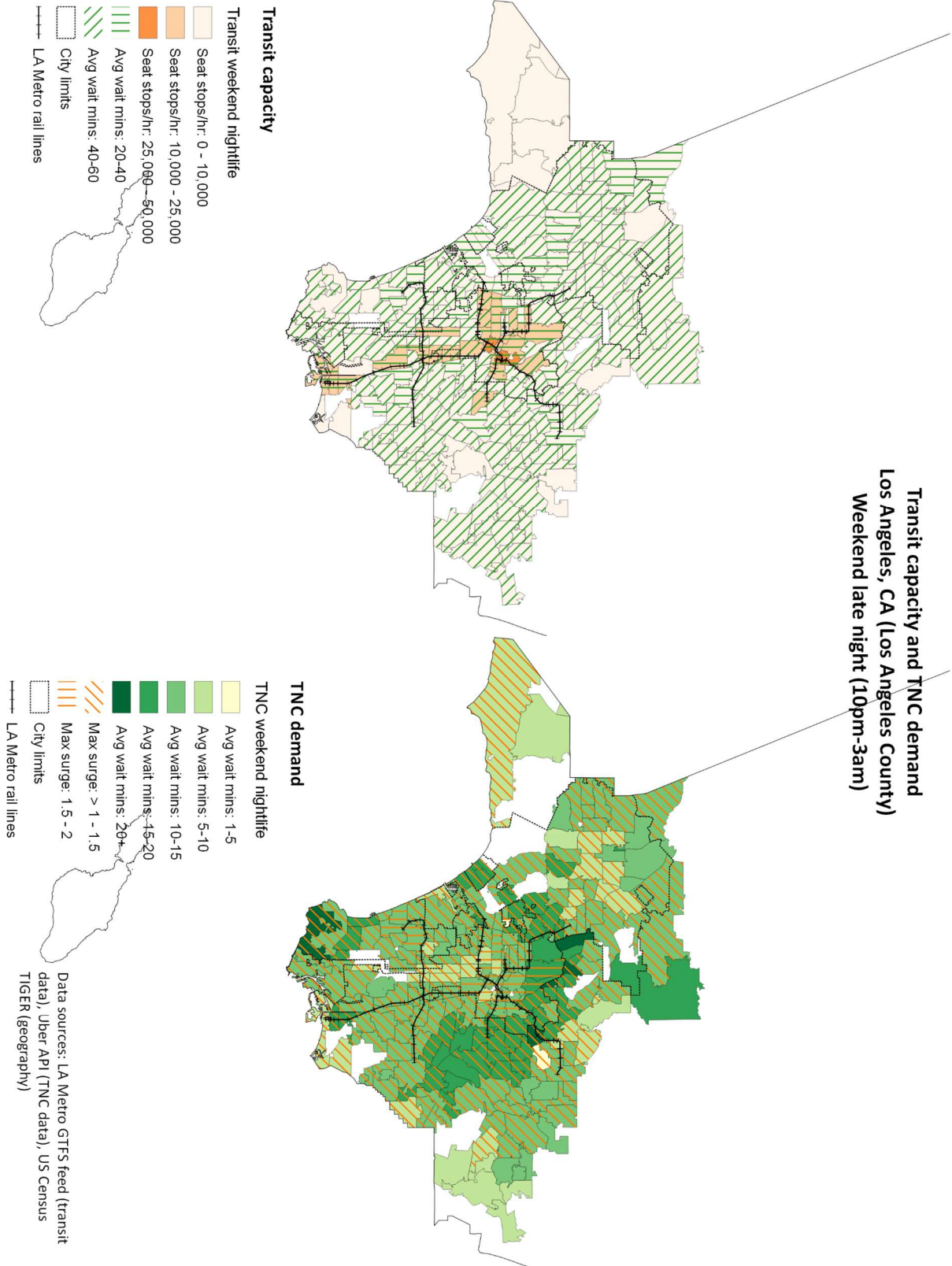


Figure F-12: Transit capacity and TNC demand, Weekend late night, Los Angeles CA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

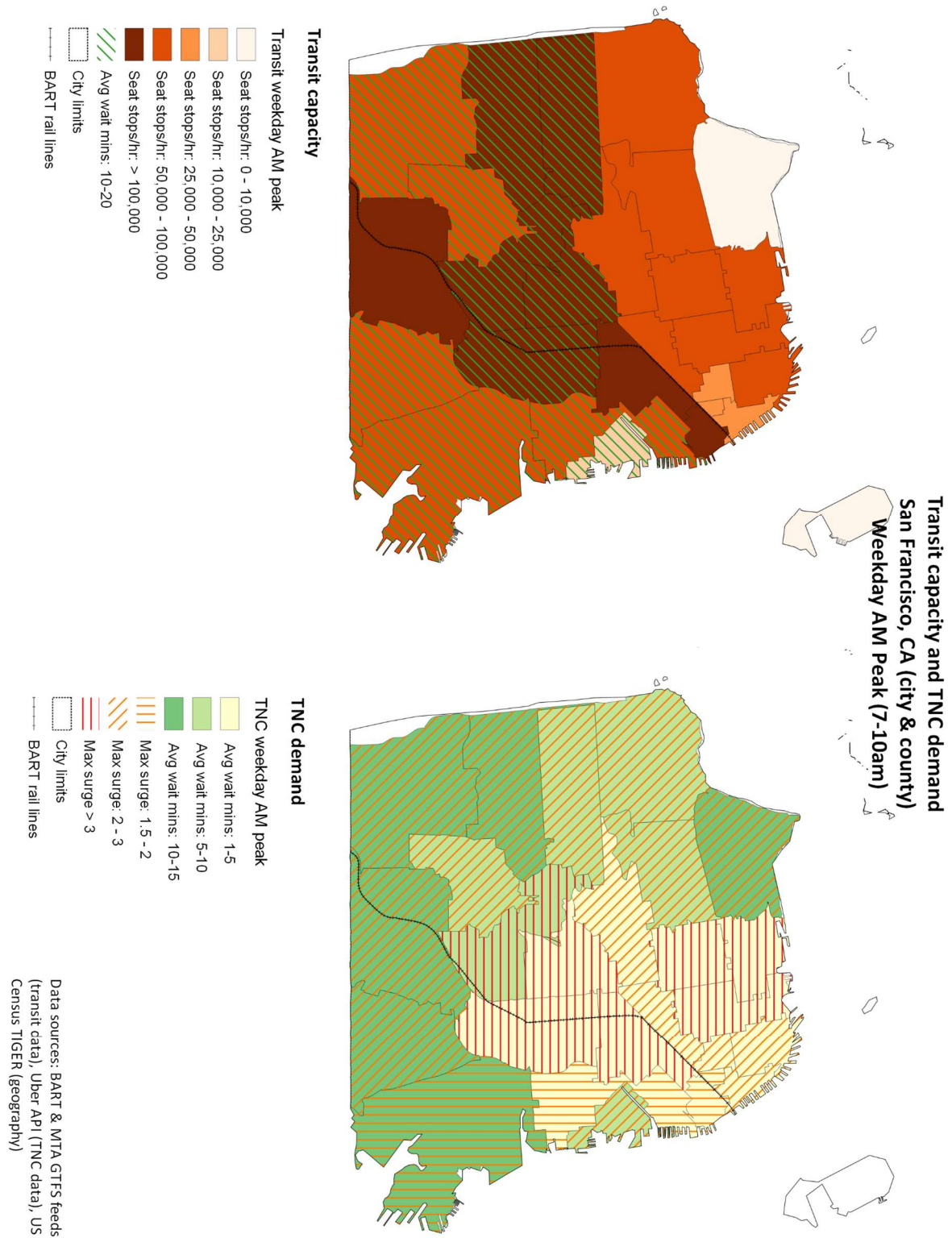


Figure F-13: Transit capacity and TNC demand, Weekday AM peak, San Francisco CA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

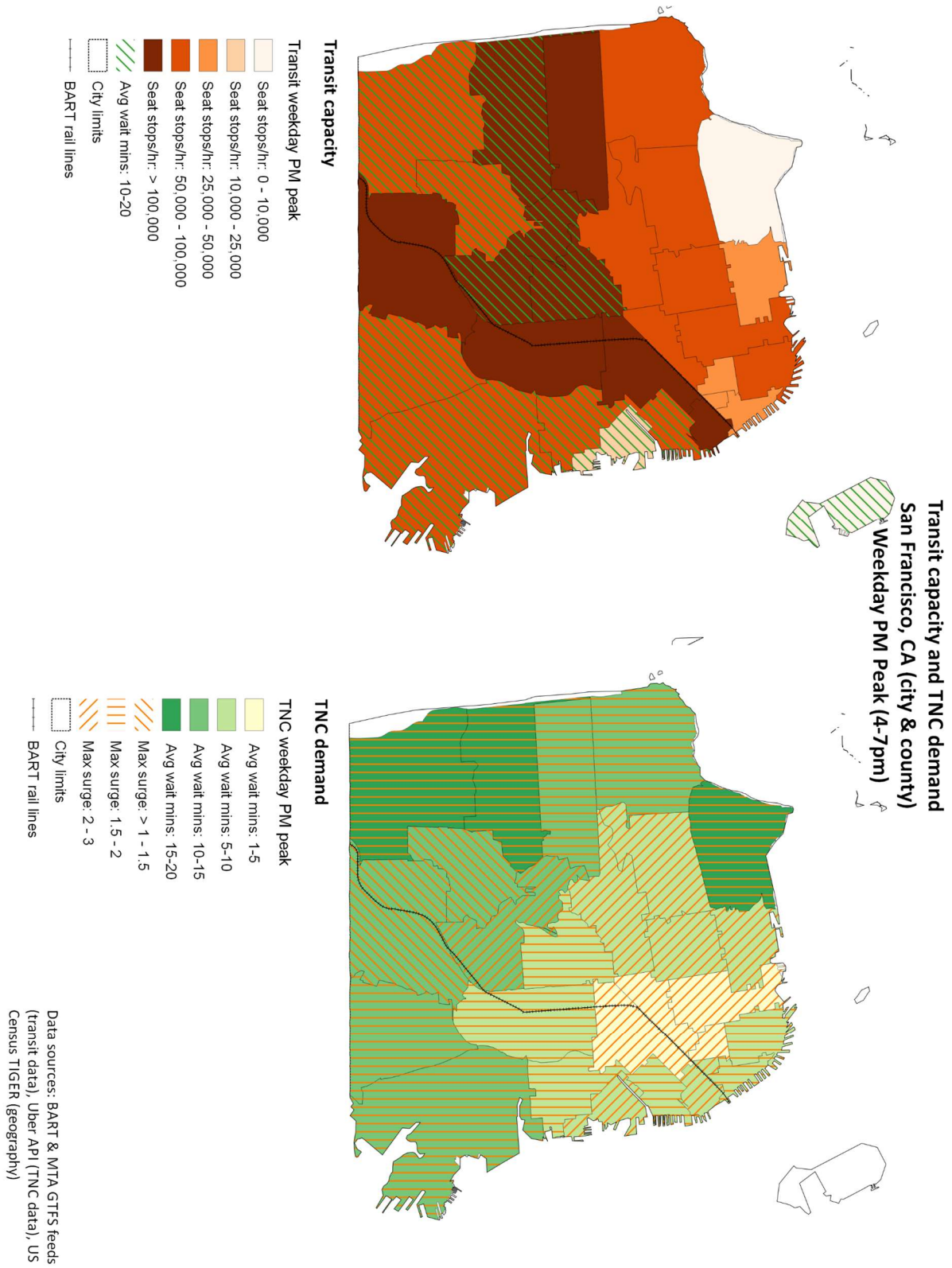


Figure F-14: Transit capacity and TNC demand, Weekday PM peak, San Francisco CA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

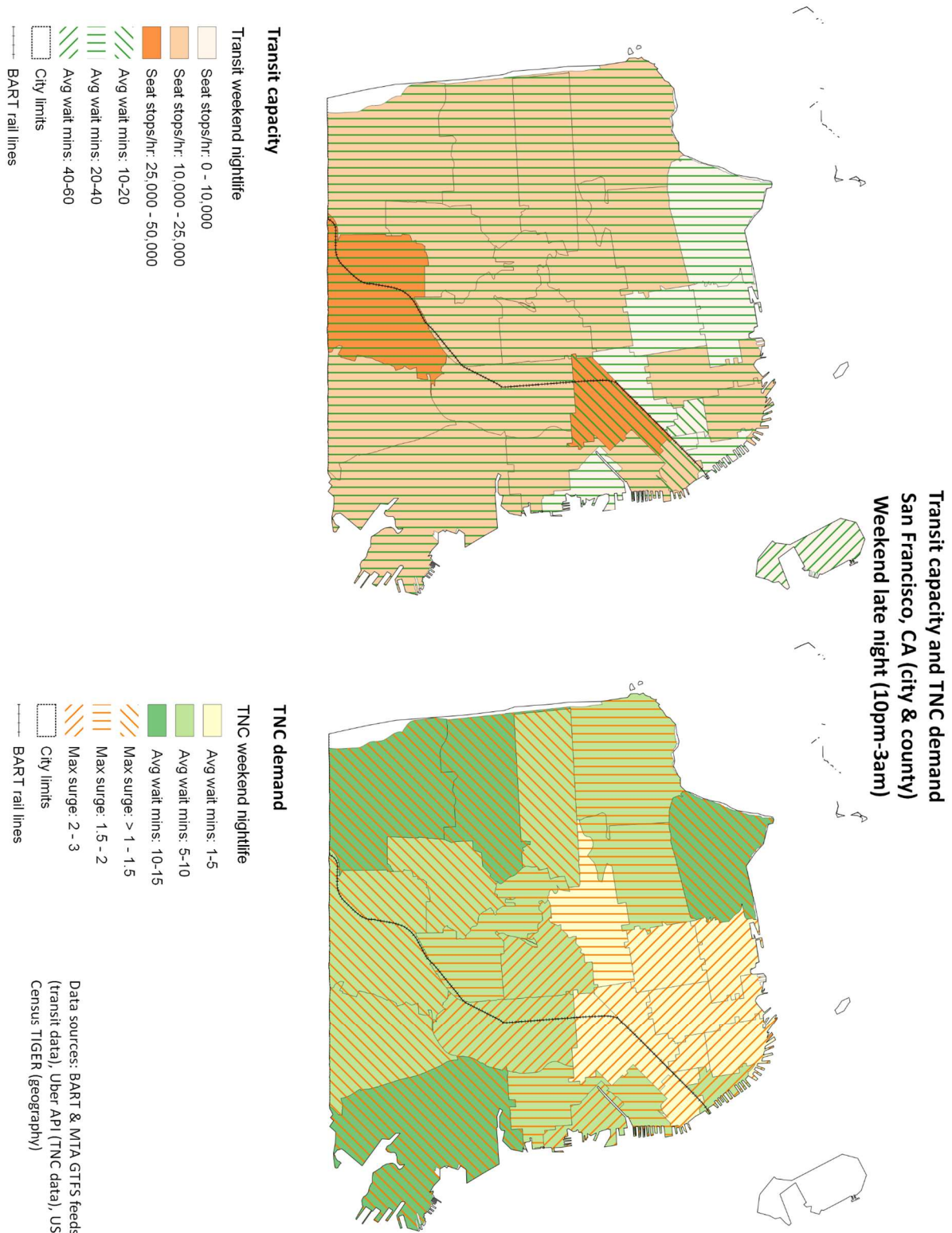


Figure F-15: Transit capacity and TNC demand, Weekend late night, San Francisco CA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

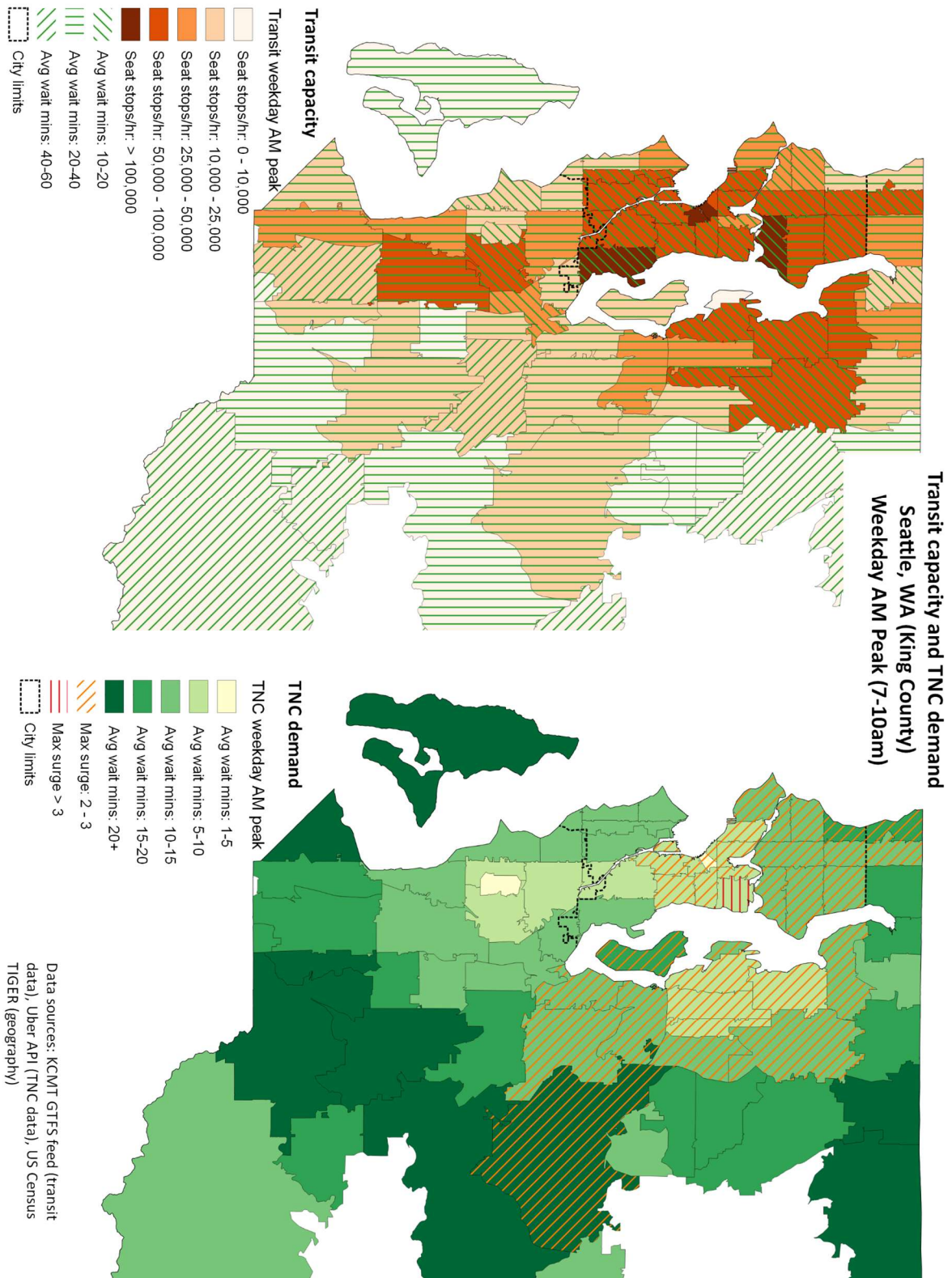


Figure F-16: Transit capacity and TNC demand, Weekday AM peak, Seattle WA

Shared Mobility and the Transformation of Public Transit
Appendix F: Maps of ridesourcing and transit demand & capacity

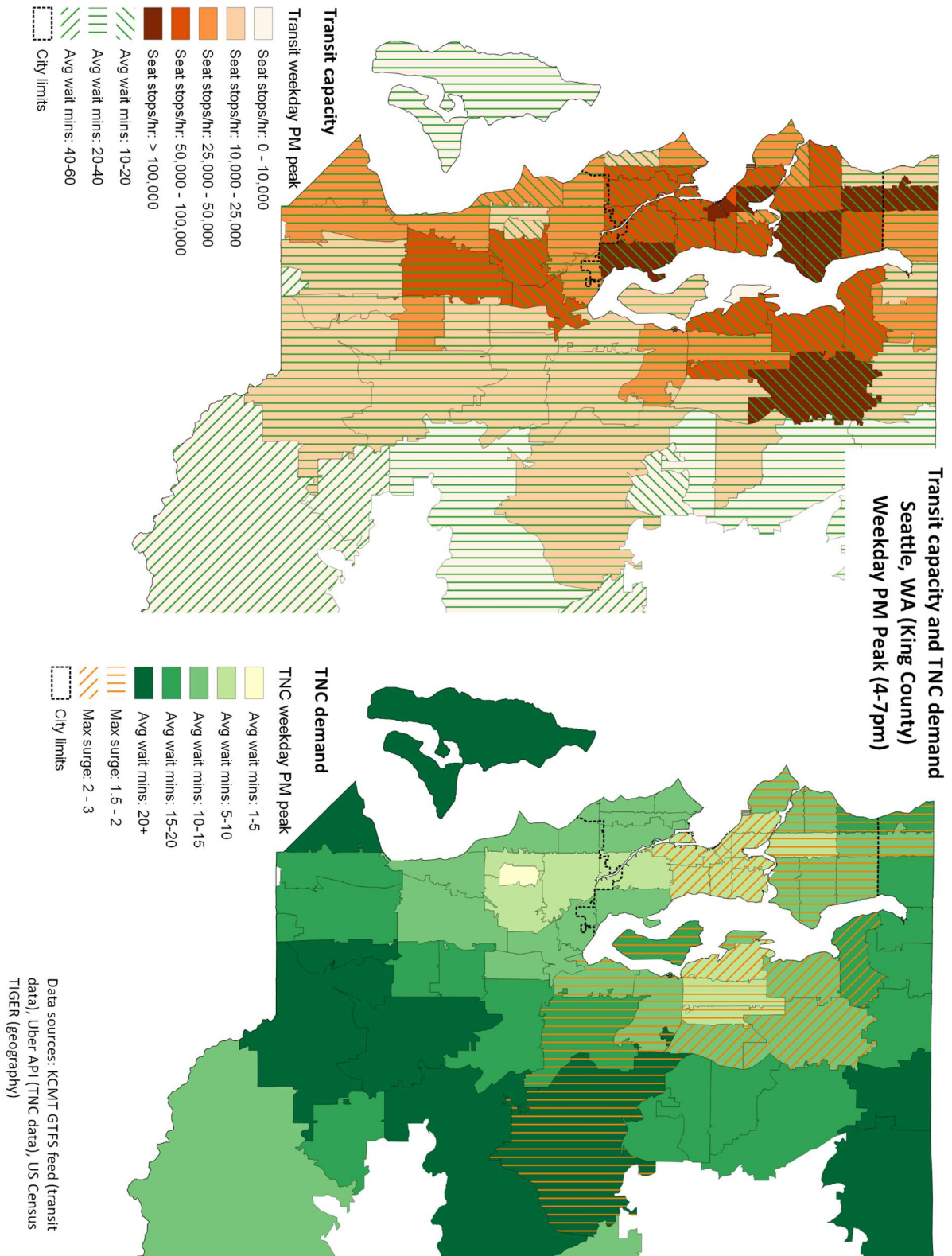


Figure F-17: Transit capacity and TNC demand, Weekday PM peak, Seattle WA

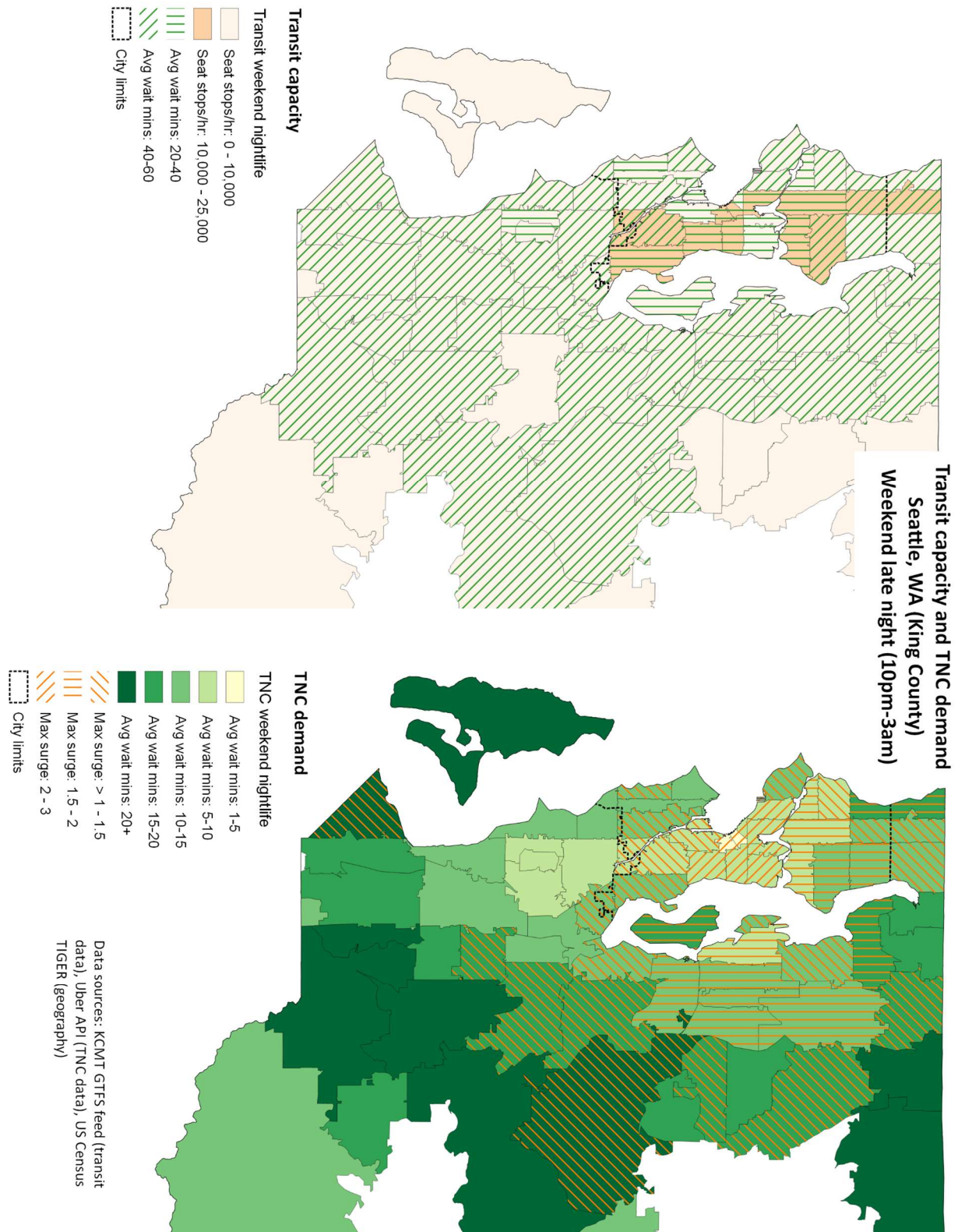


Figure F-18: Transit capacity and TNC demand, Weekend late night, Seattle WA

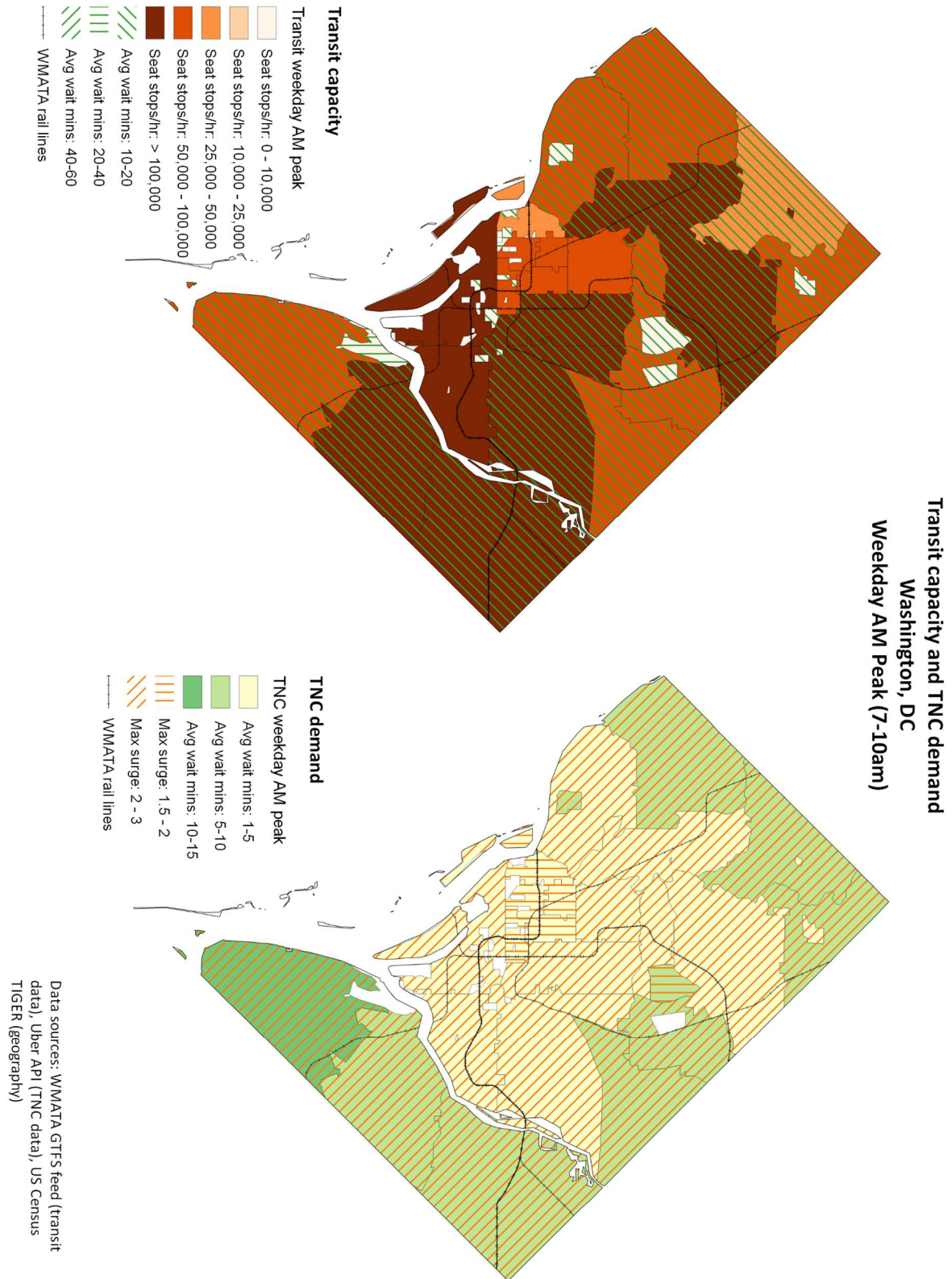


Figure F-19: Transit capacity and TNC demand, Weekday AM peak, Washington DC

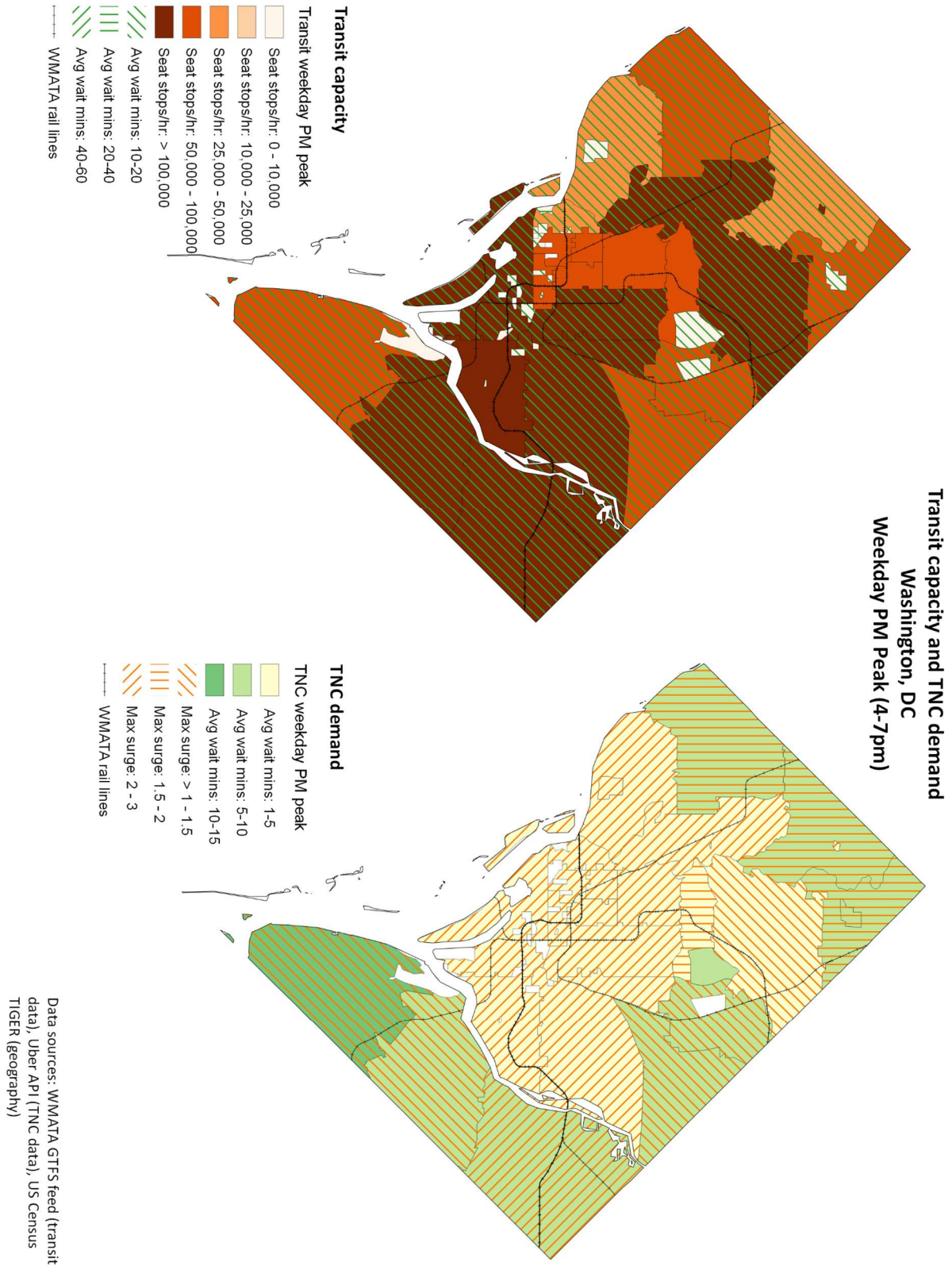


Figure F-20: Transit capacity and TNC demand, Weekday PM peak, Washington DC

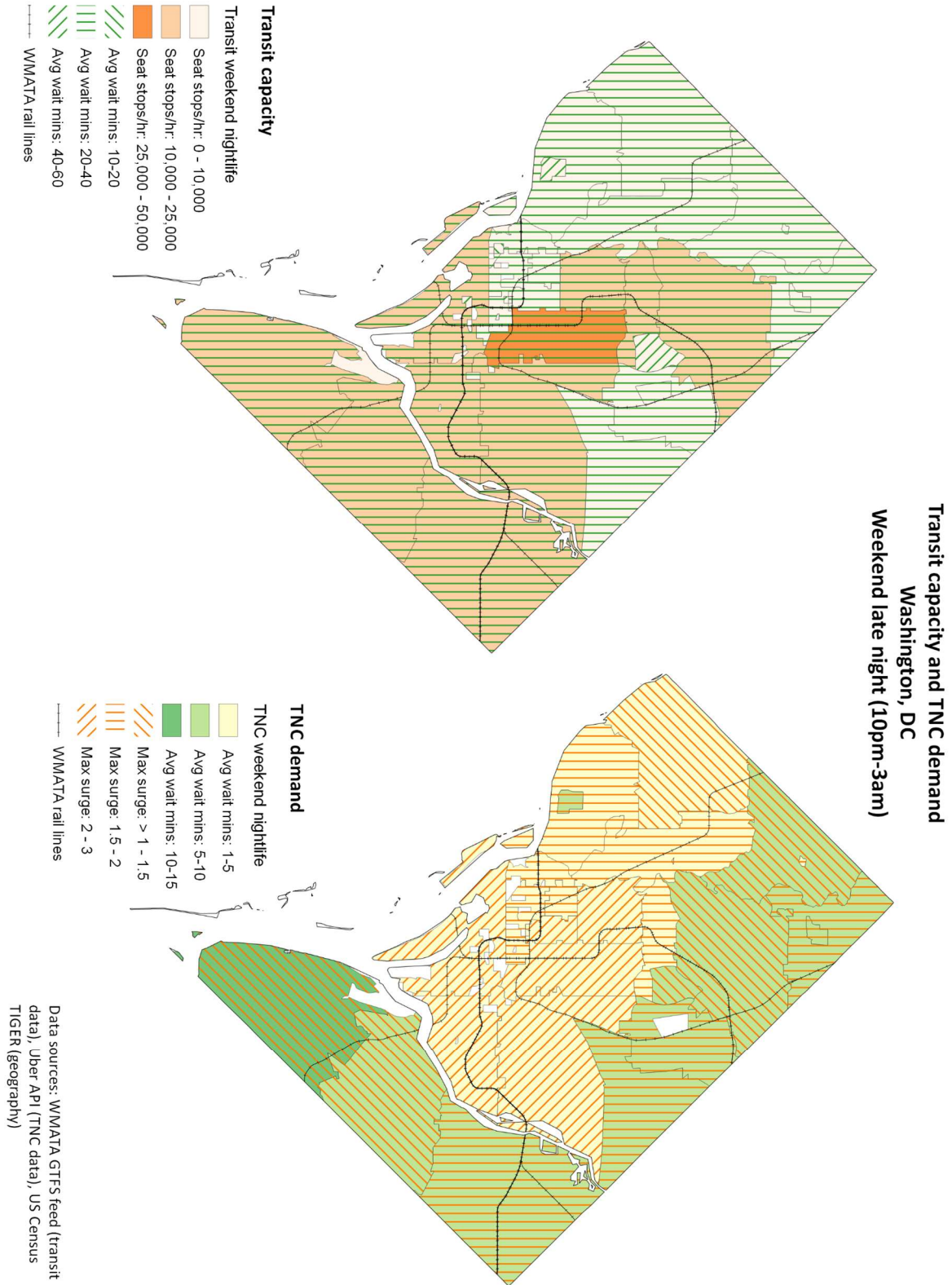


Figure F-21: Transit capacity and TNC demand, Weekend late night, Washington DC